Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

EMPIRE BUILDING | June, 1944 | PITTSBURGH, PA.

★ MESTA ROLLS ★ ★

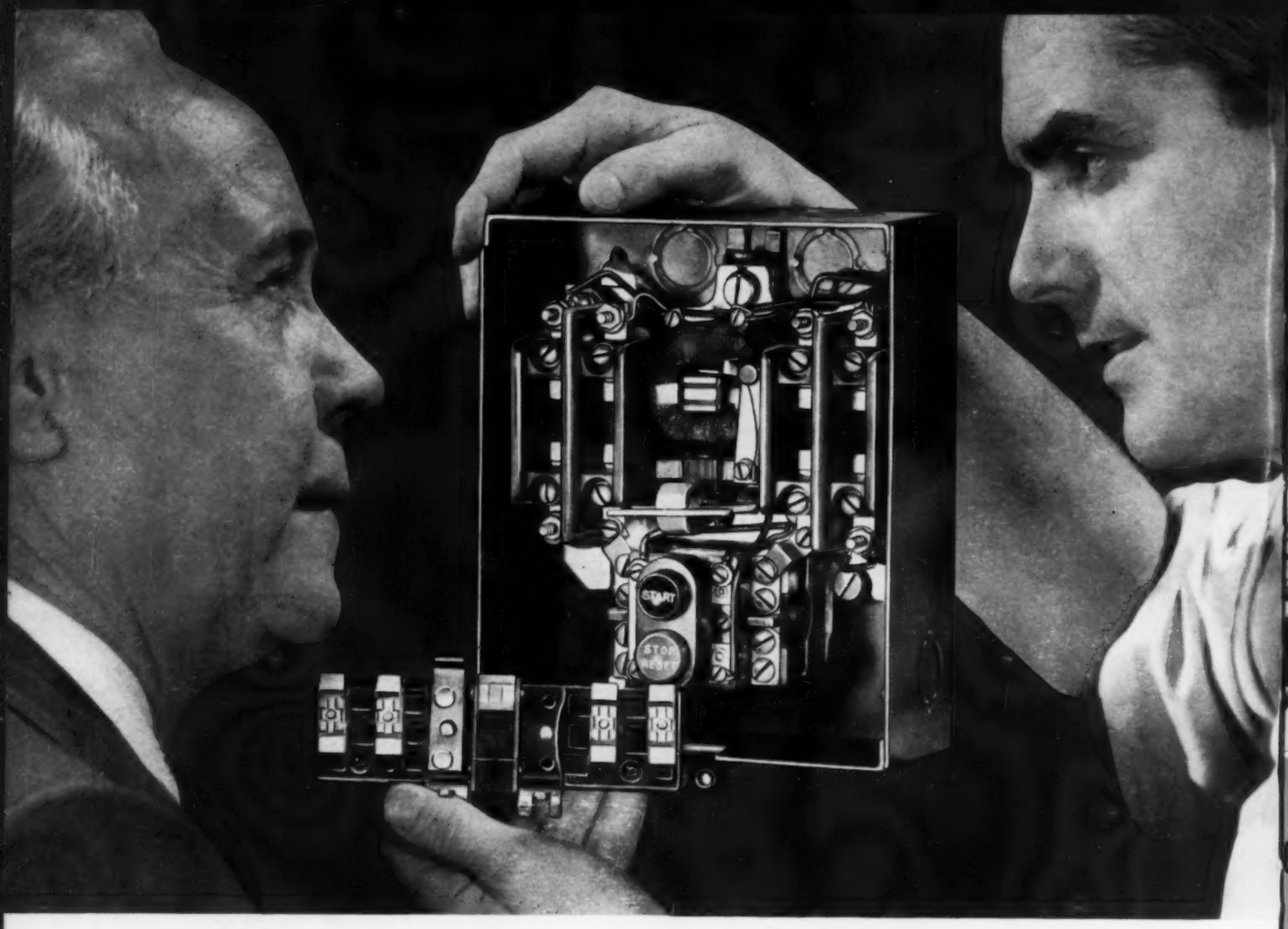
Double Pouring a 38" x 110" MESTA Chilled
Alloy Iron Plate Mill Working Roll

WAR LOAN

MORE THAN BEFORE IN THE FIFTH WAR LOAN

ARMY E NAVY

MESTA MACHINE CO
PITTSBURGH, PA.



VERTICAL CONTACTS *in Motor Control*

Superb Engineering . . . and Good Common Sense

With America's factories playing such an important part in shaping the future of mankind, *millions* of people know the vital job being done by electric motors and the resulting *importance* of dependable motor control. Thus the widespread preference for Cutler-Hammer Vertical Contact Motor Control is easily understood. Not only does the performance of *this* motor control speak for itself but the *reason* for such performance is obvious, easily appreciated, fully convincing. Electrical experts like to say the vertical contact construction in Cutler-Hammer Motor Control is superb engineering. But we rather like the way hard-boiled maintenance men put it . . . "Vertical Contacts make sense. I wouldn't buy any other kind of motor control". That tells the real story of an outstanding engineering achievement . . . why the vast majority of all electric motor manufacturers recommend Cutler-Hammer Motor Control, why leading machinery builders feature it as standard equipment, why a host of electrical wholesalers carry it in stock for your convenience. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

[redacted]

Everyone knows *clean* contacts are the *first* requirement for smooth-operating, dependable motor control. Anyone can see vertical contacts *can't* collect dust and dirt like horizontal surfaces—must *stay* clean and perform better.

[redacted]

By their very design, vertical contacts form a flue or "chimney" wherein naturally induced rising air currents act to automatically extinguish the arcing which occurs when contacts are opened. This means longer-life motor control.

[redacted]

Vertical contacts are out in the open, easy to inspect, simple to service. They are designed to *avoid* the destructive effects of confined heat and arcing . . . do not merely *hide* them until major damage develops.

CUTLER-HAMMER
MOTOR CONTROL
C-H

Copyright 1944, Cutler-Hammer, Inc.

Engineering Excellence Finds its Greatest Reward in the Respect and Confidence of those it Serves

et Aetna-Standard put your ideas on the drawing board *Now*

Coming Up With Something New is Our Business . . . .

To fully exploit the vast sales possibilities for metals in peacetime, many new methods and new equipment will have to be developed . . . some old ideas will have to be revamped.

Perhaps you have an idea for a new product or a new process, but you probably need more specific data as to the particular type of equipment that will be needed, how much it will cost and whether or not your idea is practical.

Or perhaps you are interested in investigating new developments in your industry such as the continuous galvanizing of wide strip in coils on which Aetna-Standard already has done a vast amount of research.

Whatever you have in mind, Aetna-Standard can assist, because our business since 1904 has been the originating and building of mill equipment.

Preliminary engineering on your peace plans now may save you precious time tomorrow. Enlist the services of this experienced organization in carrying forward your designs.

Your inquiry will be handled in strict confidence.

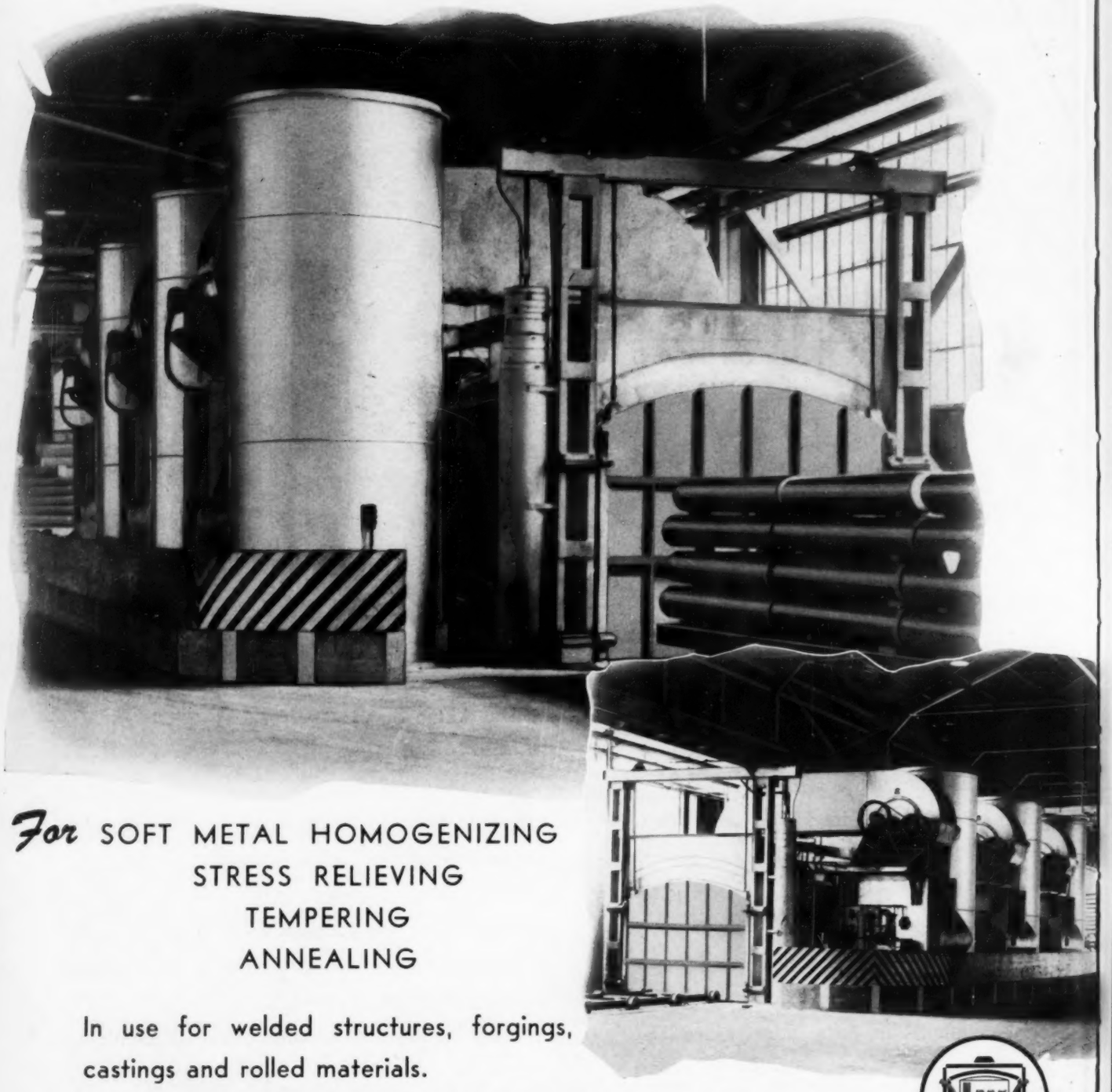
THE AETNA•STANDARD
ENGINEERING COMPANY
YOUNGSTOWN, OHIO

DESIGNERS AND BUILDERS to the Steel, Non-Ferrous and Chemical Industries.

ASSOCIATED COMPANIES:
HEAD, WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND
JOHN INGLIS COMPANY, LIMITED, TORONTO, ONTARIO, CANADA

WILSON

MULTI-ZONE RECIRCULATING GAS TYPE CONVECTION HEATING *Furnaces*



For SOFT METAL HOMOGENIZING
STRESS RELIEVING
TEMPERING
ANNEALING

In use for welded structures, forgings, castings and rolled materials.

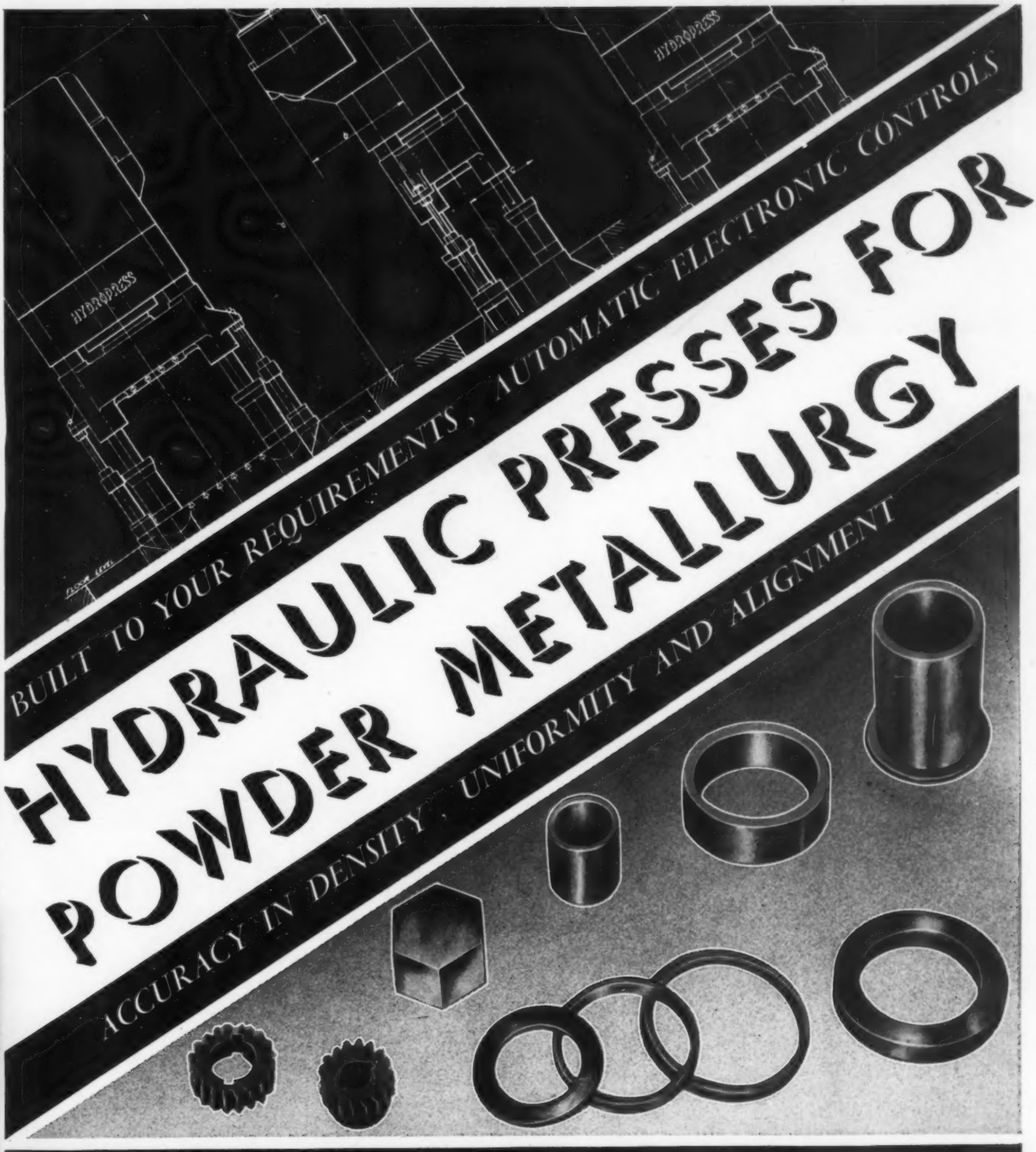
ENGINEERED AND CONSTRUCTED BY THE

Lee Wilson ENGINEERING Co., Inc.

20005 West Lake Road CLEVELAND, OHIO
Telephone ACademy 4670

The Wilson Annealing Unit is covered by Patents Nos. 1,952,402 2,068,477 2,078,356 2,081,612, 2,089,843 and other patents pending

INDUSTRIAL FURNACES • RADIANT TUBE HEATING • HEAT TREATING PROCE


HYDROPRESS
HYDROPRESS
BUILT TO YOUR REQUIREMENTS, AUTOMATIC ELECTRONIC CONTROLS
HYDRAULIC PRESSES FOR POWDER METALLURGY
ACCURACY IN DENSITY, UNIFORMITY AND ALIGNMENT

HYDROPRESS · INC.

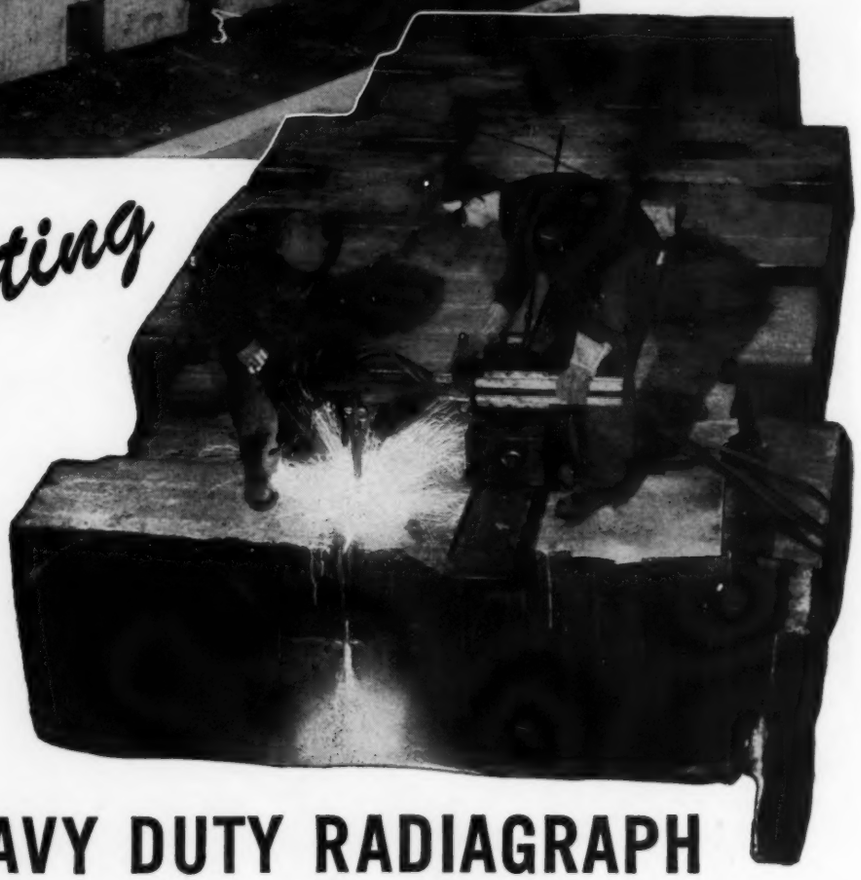
ENGINEERS CONTRACTORS

HYDRAULIC PRESSES · ROLLING MILLS
STRETCHERS · PUMPS · ACCUMULATORS

570 LEXINGTON AVENUE · NEW YORK · N. Y.

Left: Finished blank before twisting the throws to proper angles and machining operations.

Below: Oxyacetylene cutting two five-throw crankshaft blanks from a slab 10' 0" x 25' 0" x 28" thick.



Flame Cutting THICK SECTIONS *with the*

NEW AIRCO HEAVY DUTY RADIAGRAPH

Water-Cooled Torches for Heavy Cutting

For use with Heavy Duty Radiagraphs, Airco has developed a line of water-cooled torches, specifically designed for cutting thick sections.

This new gas cutting machine opens the way to important savings of time and costs in the production, from heavy slabs, or ingots, of many large, thick sections. It was especially designed for flame cutting very heavy sections (20" to more than 40") from carbon or alloy steels.

The Airco Heavy Duty Radiagraph is designed to insure accurate results. It is sturdily constructed and balanced to handle the large torches required for heavy cutting operations.

The machine is supplied for operation on either 110 volt AC (25-60 cycle) or 110 volt DC. The cutting speed ranges from 1 to 40 linear inches per minute.

For additional information, we suggest you get in touch with the nearest Airco District Office or, if you prefer, write to Department IS at the New York Office.

★ BUY UNITED STATES WAR BONDS ★

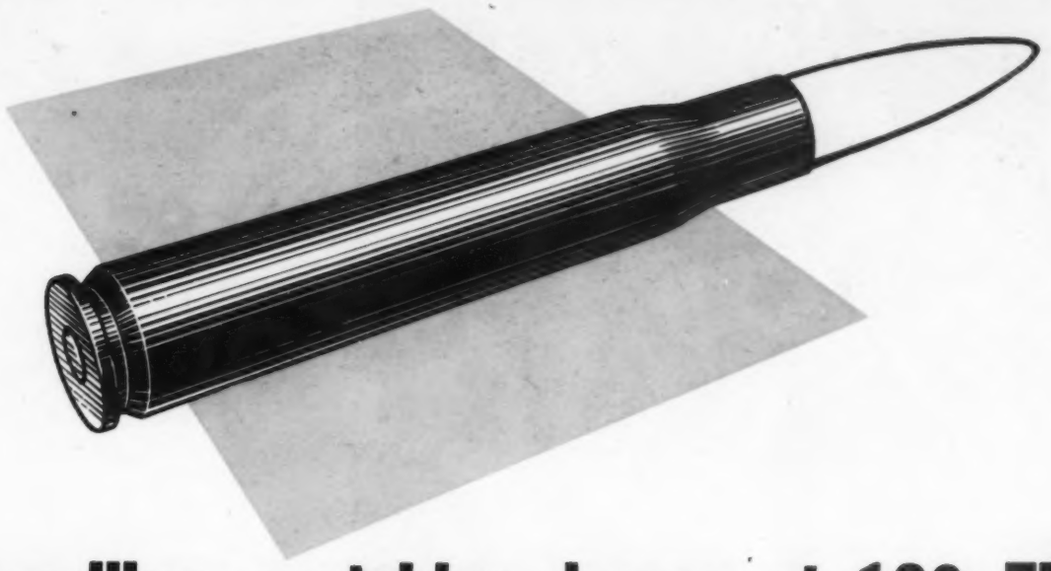
AIRCO WILSON

AIR REDUCTION

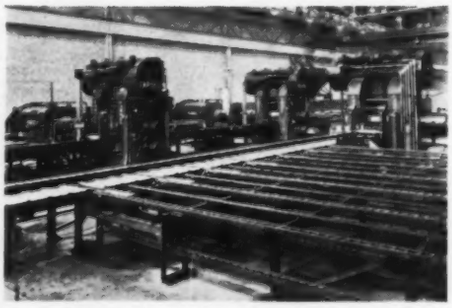
General Offices: 60 EAST 42nd STREET, NEW YORK 17, N. Y.

In Texas: MAGNOLIA AIRCO GAS PRODUCTS CO. • General Offices: HOUSTON 1, TEXAS

Offices in all Principal Cities



Cold rolling cartridge brass at 120 FPM



IN the Chicago Ordnance Plant of Revere Copper and Brass Incorporated, three Farrel 28″ x 30″ two-high mills are used for cold rundown of hard cartridge brass.

To handle the large reductions, the mills are substantially proportioned, and constructed of high-strength materials, with one-piece steel housings of heavy section. The rolls are of forged tool steel, heat-treated, hardened and precisely ground. They are carried in precision type, flood-lubricated sleeve bearings.

An important feature is the double motor screwdown built into the housings, providing ease of manipulation and facilitating setting of the rolls with extreme accuracy. Roll opening, which can be varied while the mill is in operation, is indicated by large dials on the housings and by selsyn-controlled unit on the operator's desk.

Other features include hydraulic counterbalance for the top roll, electrolimit strain gauge for indicating separating force, electrolimit flying micrometer, and roll changing rig to facilitate withdrawal of top and bottom roll assemblies as a unit.

Each mill is driven by a 1000 hp., 600 rpm. motor through a combined double reduction drive and pinion stand, to give a mill speed of 120 feet per minute. The rolls and mill pinions are connected by universal spindles, supported by a hydraulic counterbalance.

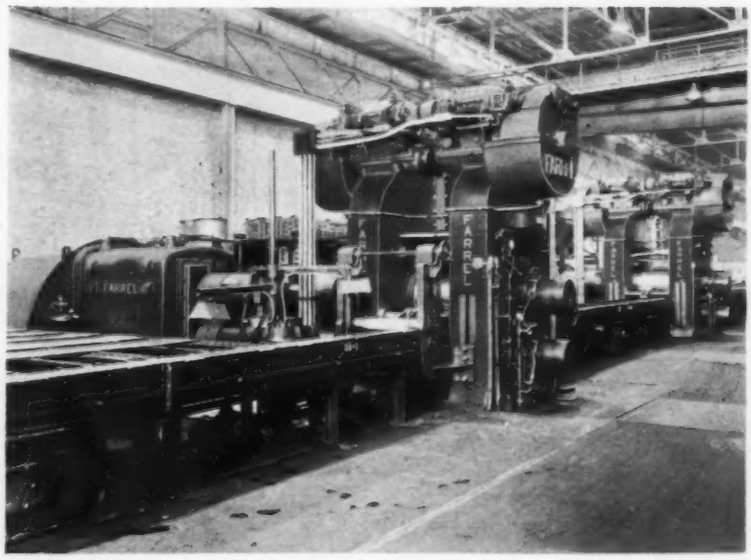
Farrel engineers are prepared to design mills to suit your requirements and will be glad to discuss your problems with you.

●

FARREL-BIRMINGHAM CO., INC.
ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo, N. Y. Sales Offices: Ansonia, Buffalo, New York, Pittsburgh, Akron, Los Angeles

Farrel-Birmingham



BONNOT PRODUCTS
ENGINEERED
FOR IMPROVED
PRODUCTION

"Say, I saw some of those Billetee in action in their mill today."

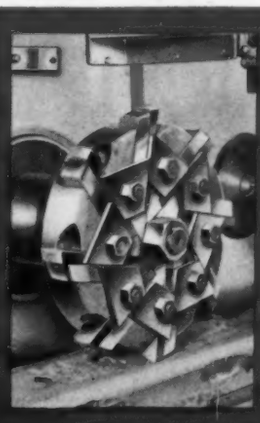
"How many do they have?"

"I counted six of them goin' to to on some eight and ten inch billet

"If every mill used them for cleani billets our expediting job wou certainly be a snap."

• YOUR BILLET •

• MECHANIZE • CONDITIONING •



Billeteers

SAVE TIME CLEAN 20 BILLETS ONE THE OLD WA

SAVE MEN FOR OTHER I PORTANT JO

SAVE METAL SALVAGE WHO HEATS THAT OO

SAVE POWER A 60 PERCE KWH SAV

Complete surfacing or spot cleaning is done faster, better and at less cost than by any other method. Write us today.

THE BONNOT COMPANY, CANTON, OHIO

BONNOT

ENGINEERED FOR IMPROVED PRODUCTION

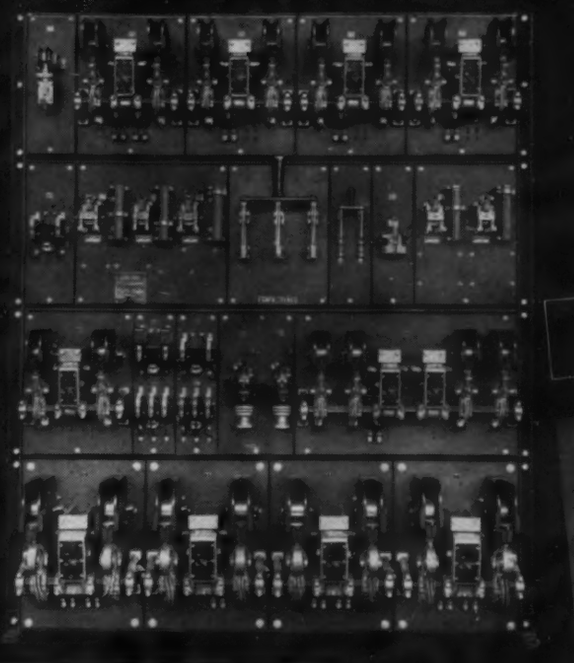
A NEW ALL A-c HOIST CONTROLLER BY EC&M

CONTRADYNE

(TRADE MARK)

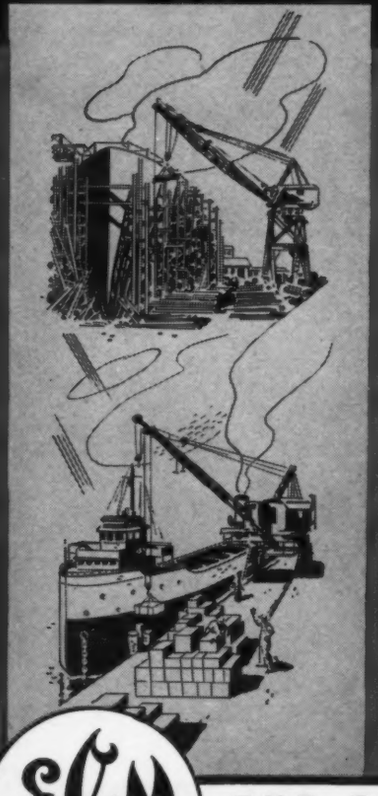
FOR SHIPWAY, FLOATING DRYDOCK, CARGO-HANDLING CRANES, ETC.

A Selective System offering a wide range of speed regulation for all loads



Typical EC&M CONTRADYNE Controller for the hoist motions of A-c cranes.

Compact Type NT Master Switch. Narrow width permits close grouping of master switches for all motions within convenient reach of the operator.



Again

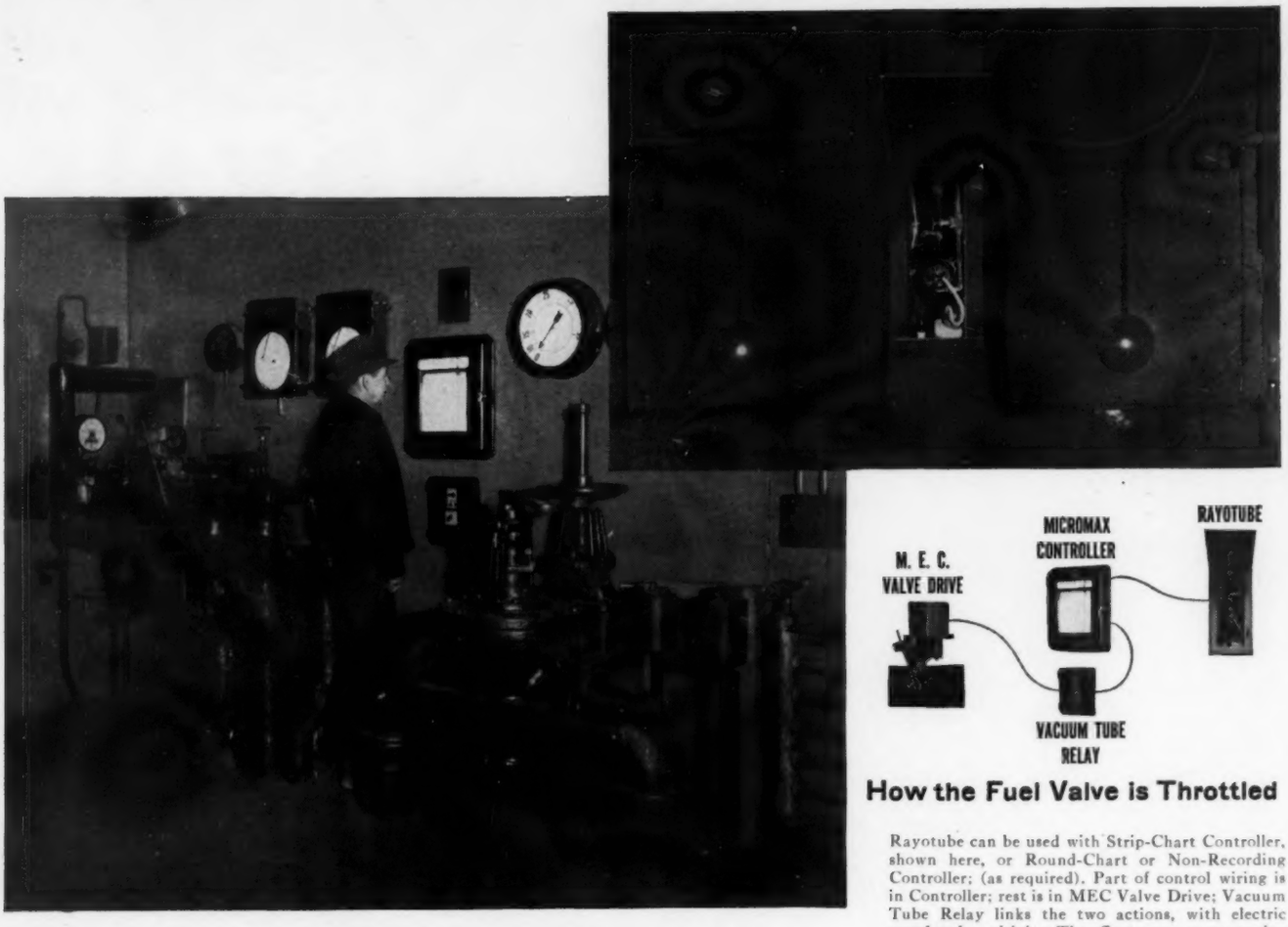
EC&M presents a new method of control for A-c crane hoist operation. Unlike any previous A-c hoist control, this controller has the following outstanding advantages:

1. Provides all the well-known advantages of the EC&M A-c dynamic lowering control for accurate handling of average crane loads (light loads or the empty hook).
2. Permits smooth regulation in the lowering of overhauling loads through long distances.
3. Used with a standard A-c wound-rotor crane motor and is operated directly from the A-c source of power without mechanical load brake or rotating conversion units.
4. Operator has control of the load at all times—brake sets instantly upon power failure or at will of the operator.
5. A simple controller of standard contactors and relays, easy to maintain and which, according to experience, requires only occasional inspection.
6. Compact and easy to install, saving valuable mounting space.

These efficient CONTRADYNE Controllers are already in successful operation on many cranes on prominent ship construction projects. Our nearby office will gladly explain the merits of CONTRADYNE Control for A-c service.

THE ELECTRIC CONTROLLER & MFG. CO.

2698 EAST 79th STREET CLEVELAND 4, OHIO



First Helper examines Micromax Roof-Temperature Controller of an open-hearth furnace.

How the Fuel Valve is Throttled

Rayotube can be used with Strip-Chart Controller, shown here, or Round-Chart or Non-Recording Controller; (as required). Part of control wiring is in Controller; rest is in MEC Valve Drive; Vacuum Tube Relay links the two actions, with electric speed and sensitivity. The effect seems as responsive as though the stable, sensitive galvanometer were tied directly to the valve, for each tiny change of temperature causes *proportional* throttling.

FURNACE OUTPUT JUMPS WITH HELP OF MICROMAX

In looking for a way to increase output, production executives of a steel mill saw a possibility in the open-hearth furnace shop. The furnaces were producing very satisfactorily; but they would certainly do even better if only some way could be found to run their bath temperatures right up to maximum, at desired times, without danger of overshooting and damaging the roof refractory.

However, temperature was manually controlled, and the First and Second Helpers were compelled to hold it well below maximum because otherwise they have to watch it more continually than they could afford. Obviously, what was needed was automatic control, which would concentrate on temperature alone. Here's how the need is met:

The principle is simply to let the roof itself limit the temperature, since it's the roof which is damaged by overheating. A Rayotube (L&N radiation detector) is mounted in such a way as to receive radiated heat from the part of the roof which will become hottest. The First Helper sets the Micromax Pyrometer's control point at the highest safe temperature of that part of the roof, and control is based on radiation from it.

To make sure the fuel isn't chopped off drastically when a small reduction might suffice (or, of course, vice-versa) the Micromax Recording Controller throttles *the fuel up and down. The fuel valve moves suddenly only if sudden action is indicated; usually it "edges" up and down — down and up again — holding temperature at the highest safe level for greatest production.*

The experience which enabled us to specify this control is available for any other industrial temperature problem. And the variety of Micromax equipments assures you of a pyrometer in which accuracy, sensitivity, speed, type of control action and other factors are combined to create a control of utmost dependability.

Jrl Ad N-33B-643(I)

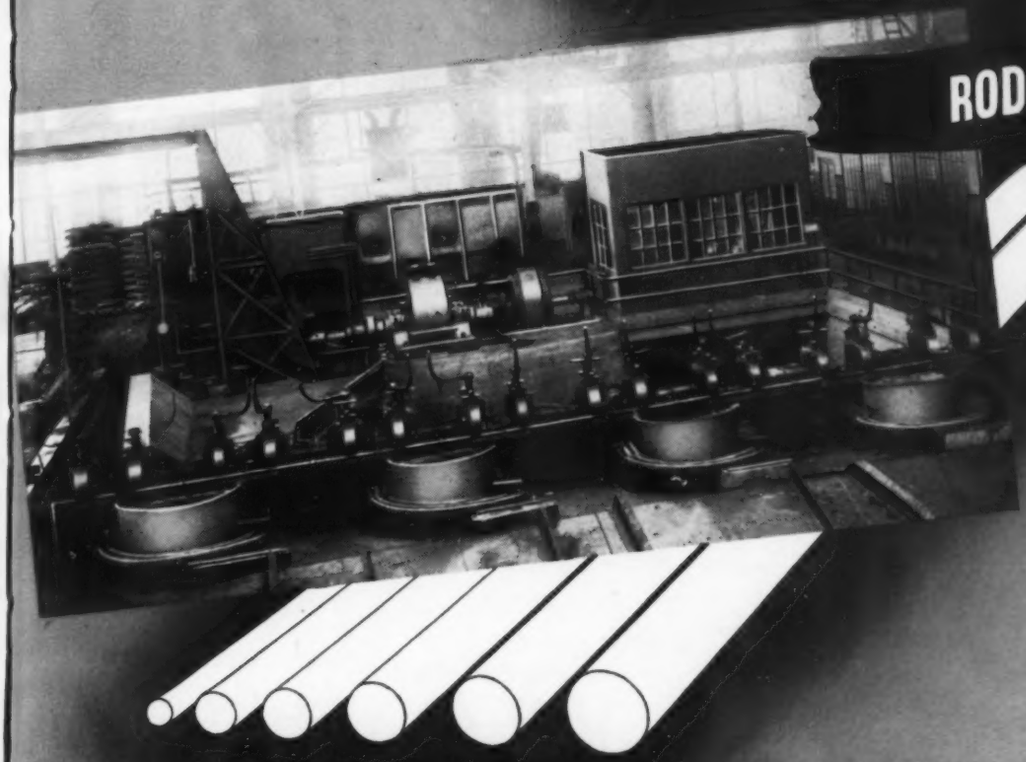
depends on me!
A Slogan For Every American

LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.
LEEDS & NORTHRUP
MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

UNITED

MERCHANT MILLS

Flexibility



ROD MILLS

Precision

FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

UNITED ENGINEERING and FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

Plants at PITTSBURGH, VANDERGRIFT, NEW CASTLE, YOUNGSTOWN, CANTON

Davy and United Engineering Company, Ltd., Sheffield, England

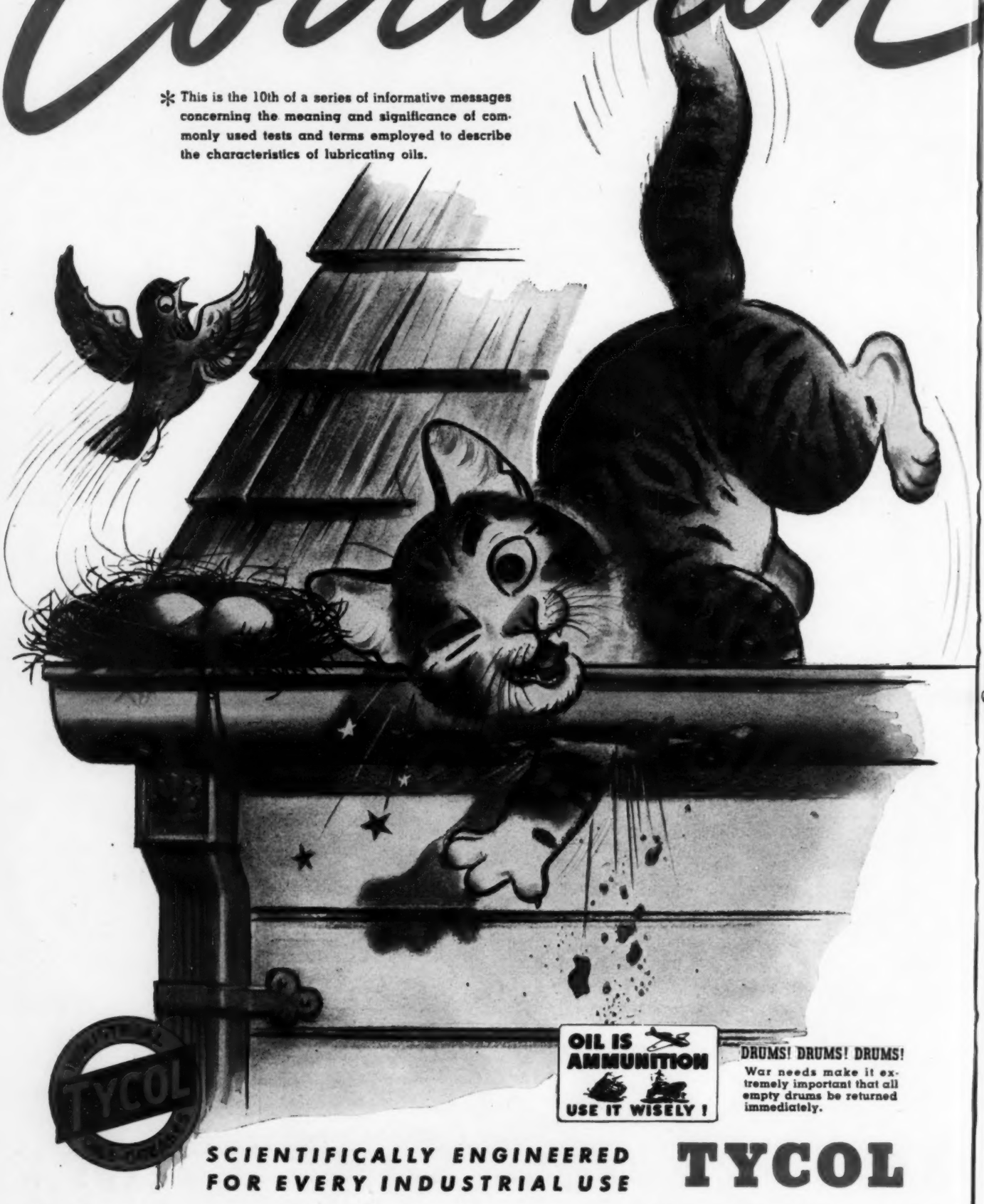
Dominion Engineering Works, Ltd., Montreal, P. Q. Canada

UE&FCO

The World's Largest Designers and Makers of Rolls and Rolling Mill Equipment

* Corrosion

* This is the 10th of a series of informative messages concerning the meaning and significance of commonly used tests and terms employed to describe the characteristics of lubricating oils.



DRUMS! DRUMS! DRUMS!

War needs make it extremely important that all empty drums be returned immediately.

SCIENTIFICALLY ENGINEERED FOR EVERY INDUSTRIAL USE

TYCOL

TIDE WATER LUBRICANIA

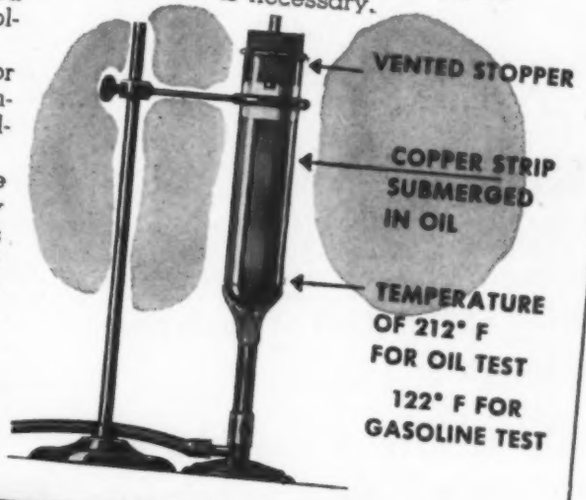
EXPLANATION: Petroleum products are frequently used in contact with metal, and when it is essential that the metal shall not be corroded, it is customary to require that the petroleum products pass an appropriate corrosion test.

TEST: The Copper Strip Corrosion Test as described in "Federal Specifications for Lubricants and Liquid Fuels" indicates the presence of free sulphur or corrosive sulphur compounds in undesirable quantities. It is conducted as follows: A clean strip of mechanically polished pure sheet copper about one-half inch wide and three inches long is placed in a clean test tube. Sufficient of the oil or liquid fuel to be tested is added to cover the copper strip completely. The test tube is closed with a vented stopper and maintained at a temperature of 212° F. for 3 hours. (If gasoline is being tested, then the temperature is held at 122° F. to avoid loss of product by distillation). The copper strip is then rinsed with sulphur-free acetone and compared with a similar strip of freshly polished copper.

The presence of free sulphur or corrosive sulphur compounds is indicated by the corrosion or discoloration of the test strip.

The sample does not "pass" the test if the discoloration of a freshly polished copper strip becomes opaque or if pitting is caused on any portion thereof. A slight discoloration is generally accepted as "passing" the test.

SIGNIFICANCE OF TEST: The Copper Strip Corrosion Test is an extremely sensitive test for indicating the presence of free sulphur or corrosive sulphur compounds in an oil. This test will detect concentrations of free sulphur as low as .001%. Variations in color of the copper strip may occur through a whole range of color shades with greens and reds predominating. Certain of these colors result from other reaction products than those caused by sulphur. These compounds may in no way be detrimental, and this fact should be taken into consideration when using this test to pass on the corrosive properties of an oil. Free sulphur colors the copper strip "black." The Copper Strip Corrosion Test is a desirable test for control of refining processes on certain types of petroleum products such as gasoline, Diesel fuel, Hypoid and All-Purpose Gear Lubricants, cutting oils and the like. It may also be used in the field for determining if sulphur compounds are present in certain oils containing additives when an active sulphur ingredient is necessary.



Tycol lubricants are made in a comprehensive line to meet each specific service requirement. Their repeatedly-proven ability to assure outstanding performance is the result of modern scientific manufacturing and rigid testing. Tide Water engineers will recommend the Tycol lubricant exactly suited to your needs – thus assuring truly efficient and economical lubrication.

TIDE WATER ASSOCIATED OIL COMPANY

MAKERS OF THE FAMOUS VEEDOL MOTOR OIL • Eastern Division: 17 Battery Place, New York 4, N. Y.

***Principal Branch Offices:* Boston, Philadelphia, Pittsburgh, Charlotte, N. C.**

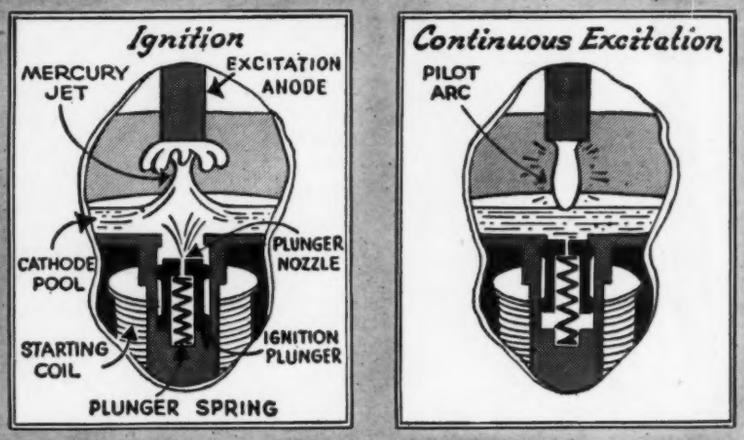
INDUSTRIAL LUBRICANTS

GET STABLE D-C

WITH EXCITRON MERCURY ARC RECTIFIERS!

Here's the Excitron Principle . . .

Allis-Chalmers Excitron employs simple, one-time ignition for "continuous excitation". To close circuit, plunger beneath mercury surface shoots jet up to excitation anode . . . which is safe distance above mercury cathode, *cannot be affected by impurities or turbulence on mercury surface.* When jet collapses, pilot arc remains.



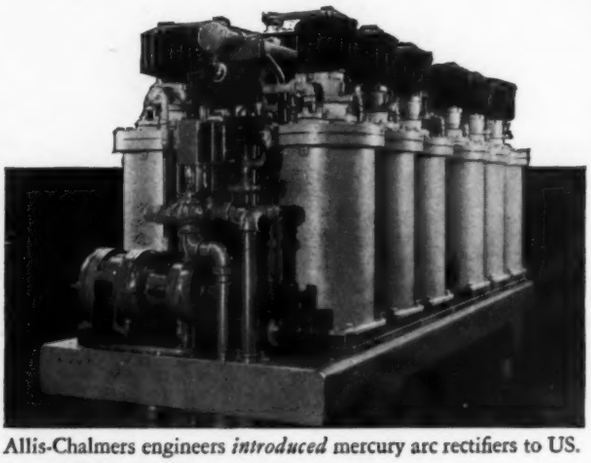
☛ Allis-Chalmers' Excitron is the only single anode mercury arc rectifier which gives you the advantages of "continuous excitation".

☛ There are no ignition impulses to be synchronized with main anode voltage. Tubes don't require re-ignition at the start of each positive half-cycle.

☛ Only Excitron uses direct current from a 3-phase source for excitation of the tube. Thus, stability of excitation cannot be affected by average single-phase dips in a-c system voltage.

☛ Excitron has a simple excitation circuit which requires no "tuning" to maintain proper wave shape. Once adjusted at factory, no further adjustment needed.

☛ Write Allis-Chalmers, Milwaukee 1, Wisconsin, for the Excitron answer to all your power conversion problems. A 1717



Allis-Chalmers engineers *introduced* mercury arc rectifiers to US.

ALLIS-CHALMERS EXCITRON MERCURY ARC RECTIFIERS

SO THE U.S.S.R. CAME TO LEWIS

LEWIS ROLLS STEP UP TONNAGE

From right next door to half-way around the world Lewis Rolling Mills have built a solid reputation for "more tonnage—with less trouble."

That reputation meant a lot to the Russian engineers for whom we recently completed the 3-High 18" Merchant Mill illustrated above. It will be working thousands of miles away from home but, like all Lewis Mills, it will turn out superior tonnage with dependable regularity.

BUY MORE WAR BONDS AND STAMPS

ARMY E NAVY

LEWIS

LEWIS FOUNDRY & MACHINE

DIVISION OF BLAW-KNOX CO.

PITTSBURGH, PA.

★ ★ WAGNER PRODUCTS FOR VICTORY ★ ★

Wagner Unit Substations are doing their part in the production of steel, synthetic rubber, oil and other vital materials.

Wagner
UNIT SUBSTATIONS
PROVIDE LOAD CENTER CONTROL FOR LIGHTING AND POWER CIRCUITS

The Unit illustrated above is installed in a synthetic rubber plant. Each transformer has a two-position liquid-filled disconnecting switch on the high-voltage side which is equipped with low-voltage interlock. The low-voltage side is equipped with air circuit breakers electrically or manually operated, ground indication lights, voltmeters, ammeters, and ammeter test blocks. Each unit has one main breaker, one tie transfer breaker, and two feeder breakers.

MOTORS
TRANSFORMERS
UNIT SUBSTATIONS
INDUSTRIAL BRAKES
BRAKE LINING

ARMY E NAVY

For Complete Information on Wagner Unit Substations write or phone the nearest Wagner branch office.

NATIONAL SECURITY AWARD

BACK THE ATTACK—
BUY U. S. WAR BONDS

T44-3

Wagner Electric Corporation
ESTABLISHED 1891
6483 Plymouth Avenue, St. Louis 14, Mo., U. S. A.
ELECTRICAL AND AUTOMOTIVE PRODUCTS

WEAN EQUIPMENT FOR THE CONTINUOUS COATING OF STRIP STEEL

THE Wean Engineering Company is meeting today's demand for equipment to produce tin plate and zinc coated strip steel with light coatings by the electrolytic method; also equipment to produce chemically treated black plate and strip steel. Equipment for coating strip steel with zinc and other materials by the hot dip method s also available.

The WEAN ENGINEERING COMPANY, Inc.
Warren, Ohio
Subsidiary Company
THE BRODEN CONSTRUCTION CO.
CLEVELAND, OHIO

SPECIALISTS IN SHEET, TIN AND STRIP MILL EQUIPMENT

Alliance 20 ton crane designed and built by The Alliance Machine Co.

New Alliance Floor Type Ingot Charging Machine - - - one of the world's largest

This Ingot Charging Machine shows that The Alliance Machine Company is still living up to its slogan—"The World's Largest Builders of the World's Largest Cranes." We have built into this machine features that have been developed and tested in the course of our 42 years of engineering and shop experience, and it is little wonder that when steel mill engineers are confronted with unusual problems, involving the handling of the smallest ingot to the 300 ton ladle of molten steel, that Alliance is consulted.

This machine is designed to grip, lift and swing a 20 ton ingot at a radius of 28 feet. The rigid cast steel upper revolving frame turns on conical rollers supported on a one piece cast steel lower frame so designed that the conical rollers operate in a bath of oil.

Great stability had to be provided in this Charger to successfully handle the heavy cantilever loads. This accounts for the ponderous sizes and 400,000 pounds of weight. Both the trolley and bridge are equipped with 8 rolled steel track wheels housed in cast steel compensating trucks. This construction provides smooth operation and reduces the wheel loading to a minimum.

An oil hydraulic system supplies the power for the hoisting and gripping cylinders. Contact rails located in a trench, under the bridge, supplies the necessary operating electric current.

LADLE CRANES . GANTRY CRANES . FORGING MANIPULATORS
SOAKING PIT CRANES . STRIPPER CRANES . SLAB AND BILLET
CHARGING MACHINES . OPEN HEARTH CHARGING MACHINES

ARMY NAVY E

Alliance

THE ALLIANCE MACHINE CO., ALLIANCE, OHIO - Pittsburgh Office: 1622 Oliver Building

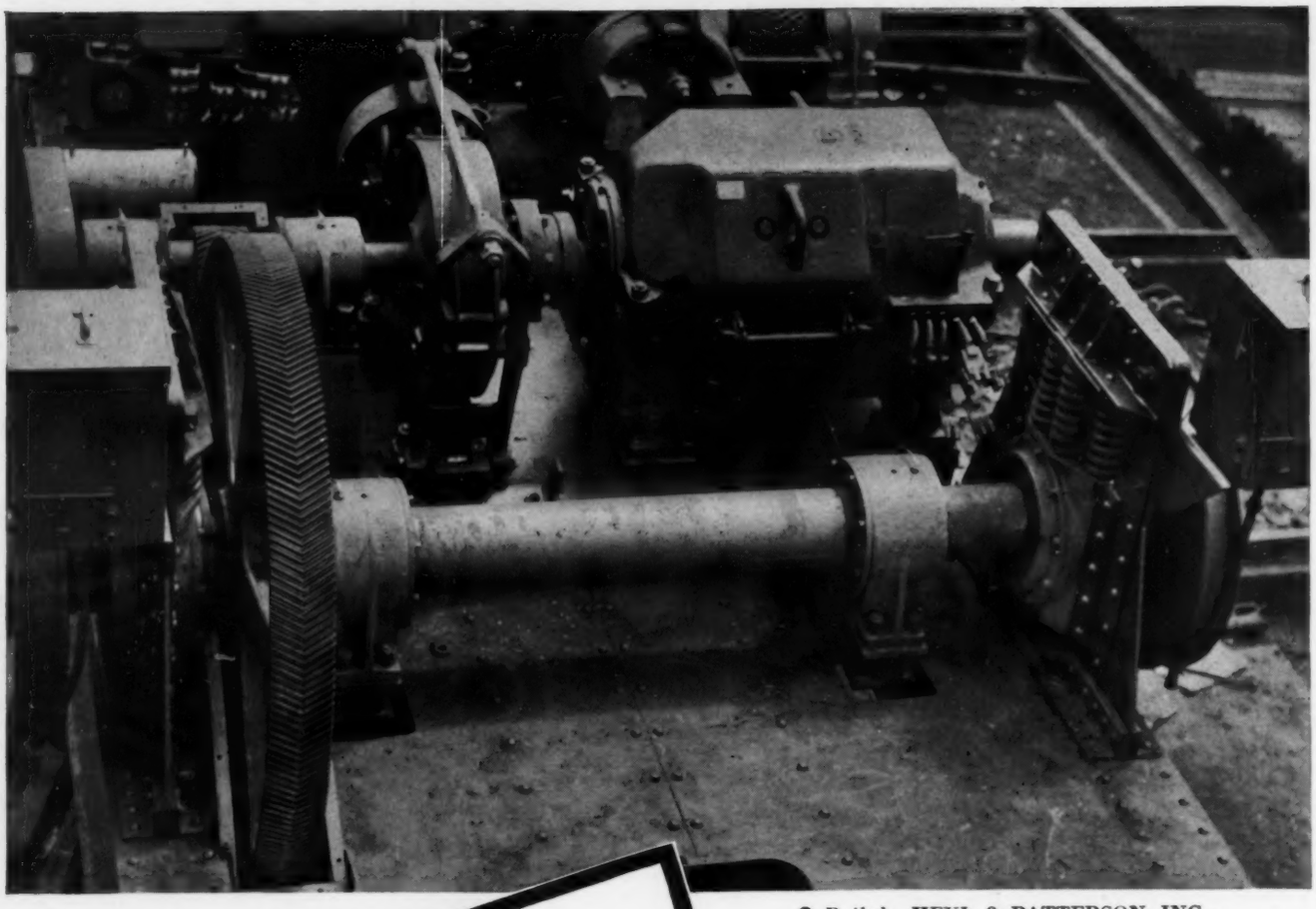
but . . . we can show you how
to give it the sales appeal of extra strength

use **Heppenstall Forgings**

Makers of Heppenstall Automatic Safe-T-Tongs

Maybe you can't "spot" all of tomorrow's markets but you can be darn sure that your product will have better market*ability* if its vital parts are good forgings . . . Heppenstall Forgings have long demonstrated their superiority. In items like alloy billets, back-up roll sleeves, rings and carbon or alloy shafting, they give your product a "tough backbone" that means greater service—*and sales* . . . Incidentally, if you make drop forgings, specify Heppenstall Harniem Die Blocks—they deliver more forgings per sinking. Let us prove these statements. Write Heppenstall Company, Department TP, Pittsburgh, Pennsylvania.

Heppenstall Company



● *Built by* HEYL & PATTERSON, INC.

Bearings for ore bridge trolleys

SKF

BALL AND ROLLER BEARINGS

It takes good bearings for ore bridges. That's why the Trolley Axle and Motor Cradle bearings are SKF Self-Aligning Spherical Roller Bearings.

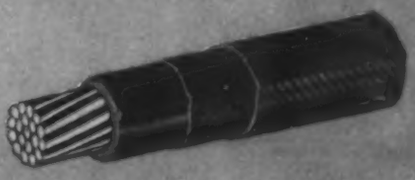
Compact, self-aligning and having high radial and thrust capacity, SKF's are unaffected by dynamic and static misalignment, distortion, weave and warpage . . . require no adjustment. Their low friction assures easy starting and running, and their infrequent lubricant requirements reduce maintenance to a minimum.

Reliability is the yardstick by which such equipment is measured. 5562

SKF INDUSTRIES, INC. • FRONT ST. & ERIE AVE. • PHILADELPHIA 34, PA.

1844 - One Hundred Years of Telegraphy - 1944

from the needs of telegraphy Okonite wire and cable research was born



JOHN HAVEN CHEEVER, pioneer rubber manufacturer, was started on the great research job that ended in his founding The Okonite Company when his friend Samuel F. B. Morse suggested the need for a rubber insulation that would protect telegraph wires in damp places.

Cheever succeeded and Okonite's first major work was in supplying covered telegraph wire that helped our fast expanding nation get its messages through, despite trying conditions of heat and moisture.

So it has been for 66 years. As insulated wires and cables were needed for new developments, Okonite research supplied them; frequently our investigations have indicated far reaching possibilities in cable insulations and cable construction which have found valuable applications. In a number of instances we have developed new synthetic compounds which time has proved are superior in many respects to those made from natural materials.

Okonite research is not an abstract, theoretical venture. It's a down to earth, practical branch of our business. Its results are of benefit to — and available to — all our customers. It's both general, in a broad sense, and very specific in its search for perfection and discovery in individual fields.

A report, made over 50 years ago, on Okonite Cables by English scientists who found Okonite Insulation "excellent".

For a discussion of Okonite wire and cable research, with concrete examples, write for Bulletin OK-1005A, a well illustrated 36 page booklet.

The Okonite Company, Passaic, New Jersey.

OKONITE

Insulated Wires and Cables

THE DERIVATION OF OKONITE

OK — *A signal flashed by telegraphers indicating message got through.*

O — *To aid in pronunciation.*

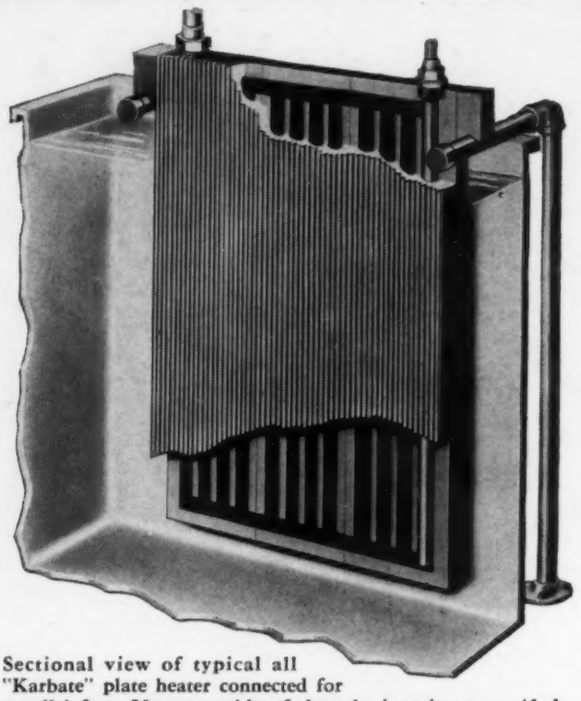
NITE — *A suffix used in the early days (as in "vulcanite") to signify "insulation".*

3068

For Greater Serviceability

KARBATE
TRADE-MARK
PLATE HEATER

The "Karbate" Plate Heater is a new departure in heaters for pickling tanks, plating tanks or other services where heating, or cooling, of corrosive liquids is required. For greater serviceability through increased resistance to mechanical shock, special construction combines tubular channels in unit blocks of "Karbate" corrosion-resistant material.



Sectional view of typical all "Karbate" plate heater connected for parallel flow. Note assembly of three basic units to specified size and "Karbate" shoulders for support of heater. Other types of supports are available.

Features of the "KARBATE" Plate Heater

- **"Karbate" material is chemically inert . . . resists practically all acids, alkalies and solvents.**
- **Thermal conductivity of "Karbate" equipment is higher than that of most materials used for such installations.**
- **Fluted sides utilize principles of extended surface for greater heat transfer.**
- **Channels can be arranged in parallel or series flow for heating or *cooling* liquids.**
- **No dilution of tank contents.**
- **Sturdy construction minimizes maintenance costs.**

The "Karbate" Plate Heater is available in four separate design groups and 30 different combinations to meet almost any service requirement. Our representative will be glad to furnish details. Write National Carbon Company, Inc., Cleveland 1, Ohio, Dept. 36F

The registered trade-mark "Karbate" distinguishes products of National Carbon Company, Inc.

★
BUY UNITED STATES WAR BONDS
★

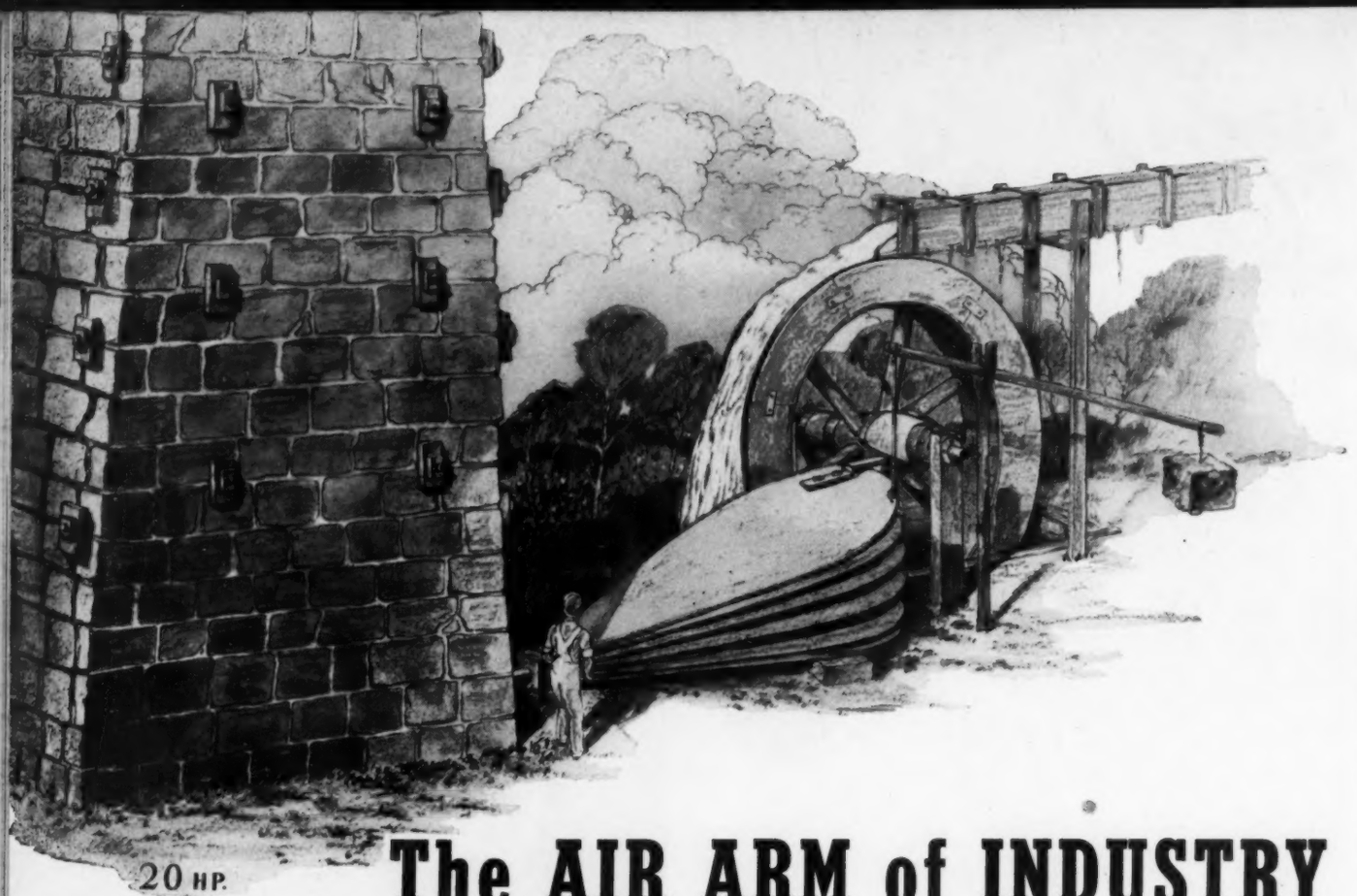
NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

CARBON PRODUCTS DIVISION, Cleveland 1, Ohio, New York, Pittsburgh, Chicago, San Francisco

REPUTATION
BUILDERS
If your plant has a reputation for dependable delivery of steel shapes rolled to unusually close tolerance, it's more than likely that your stands are equipped with Pittsburgh Rolls. They're noted throughout the industry for accuracy at high speeds—which means . . .
LESS COST PER TON OF STEEL ROLLED!
PITTSBURGH ROLLS
PITTSBURGH ROLLS DIVISION of BLAW-KNOX CO. — "Steel's Partner" — PITTSBURGH, PA.



Water power converted to air power is illustrated in this artist's drawing based on sketches of a cold blast charcoal furnace worked in the early part of the 19th century. The man standing in front of the bellows gives a proper sense of the plant proportions. (From Two Centuries of Iron Smelting in Pennsylvania by Richard Peters, Jr.).

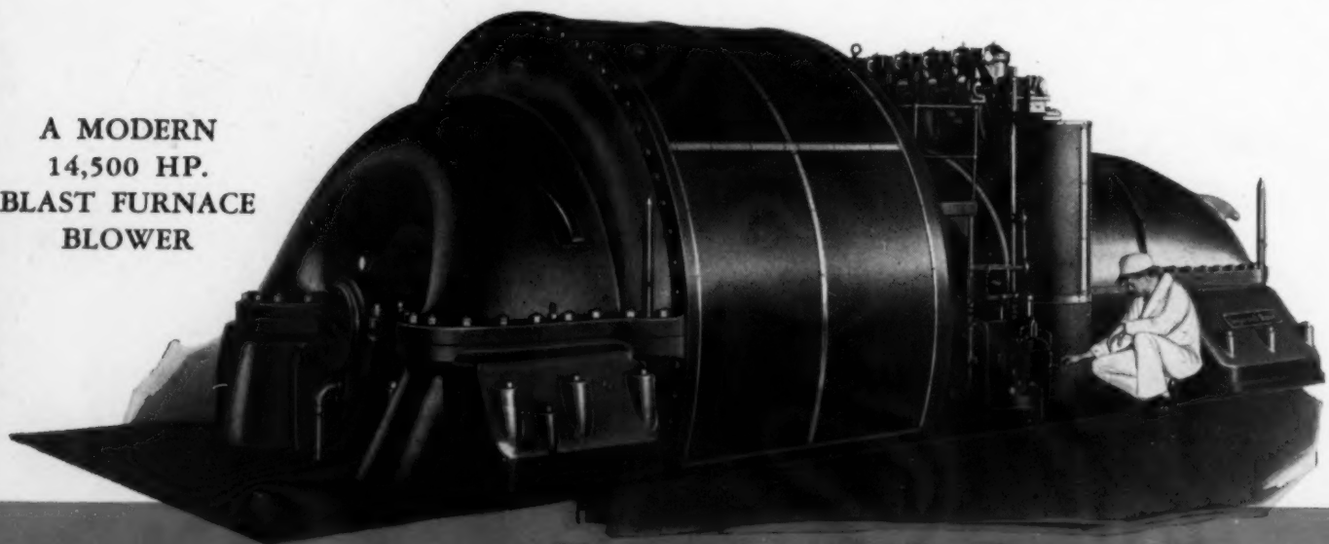
The AIR ARM of INDUSTRY

Since man first blew or fanned a faltering fire, he has been experimenting with compressed air as a means of aiding combustion. The ingenious water-wheel bellows was one of his early efforts—one of many steps toward present day record-breaking production of metals.

Today it is the Turbo Blower that furnishes the air blast. These compact, centrifugal machines compress huge volumes of combustion air for the nation's furnaces and converters. Since 1913, when the first I-R Blast Furnace Turbo Blower was installed, Ingersoll-Rand has maintained its leadership in this field.

Other industries are using thousands of I-R Turbo Blowers for compressing air or gas for a multitude of purposes. Ingersoll-Rand's 30 years' experience in building blowers of all capacities totalling several million horsepower is back of the highly efficient designs available today in sizes of from 2 to 15,000 horsepower.

A MODERN
14,500 HP.
BLAST FURNACE
BLOWER



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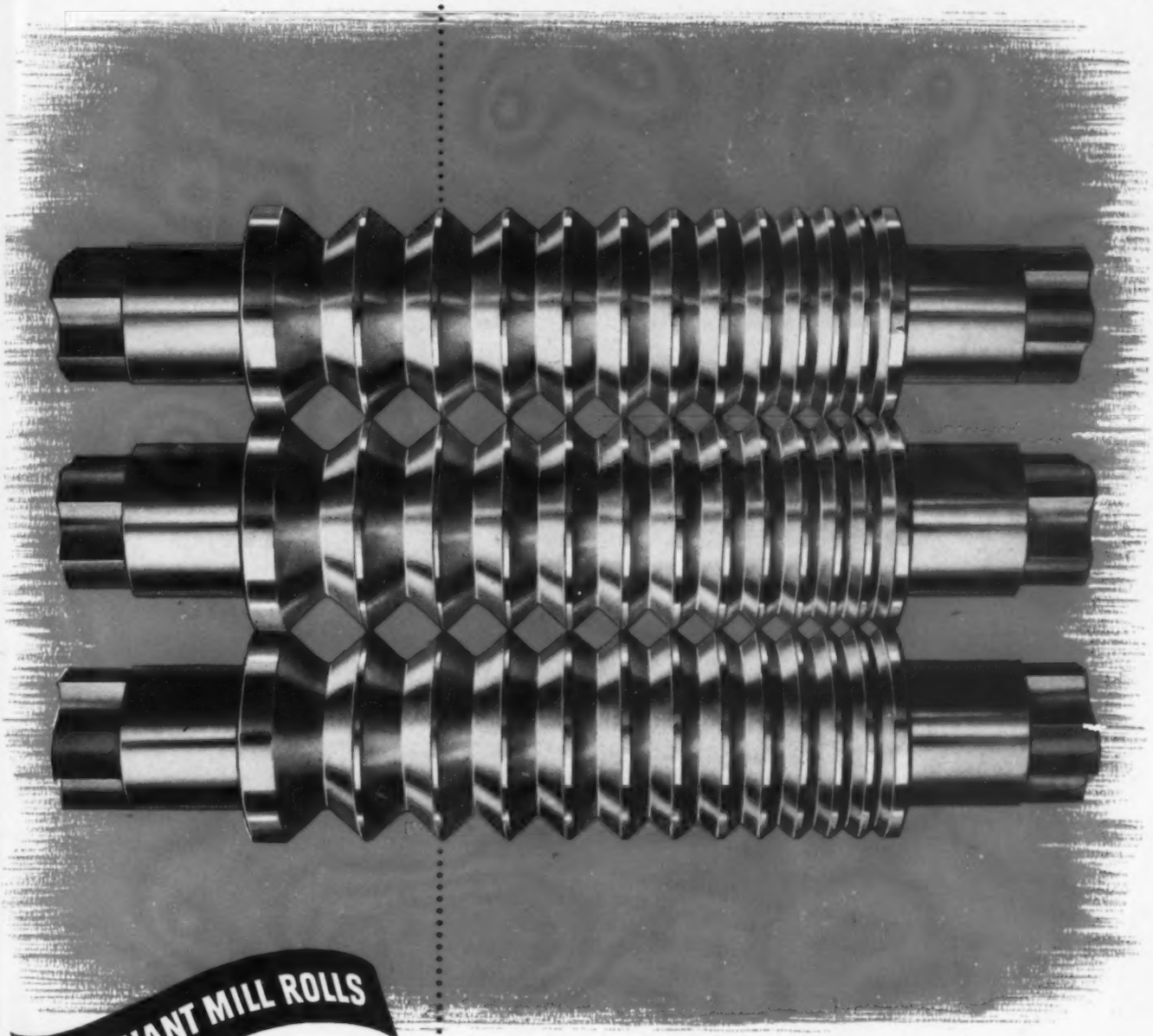
CENTRIFUGAL PUMPS CONDENSERS COMPRESSORS TURBO BLOWERS ROCK DRILLS AIR TOOLS OIL AND GAS ENGINES

Perfection in Roll

DESIGN AND MANUFACTURE



MERCHANT MILL ROLLS

Because they meet those important requirements of low cost, high speed, quality steel production, Continental Rolls are the choice of mill operators everywhere. Continental Rolls reflect the engineering skill of fine design combined with highest manufacturing craftsmanship to achieve roll perfection.

Continental offers a ready solution to your roll problem, no matter what it may be,—with structural rolls designed to roll the simplest or most intricate shapes, to hot and cold strip mill rolls made to roll plate or high quality, satin smooth, strip steel. Next time specify Continental—it's a wise choice.

In addition, Continental manufactures Carbon and Alloy Steel Casting, designs and builds complete mills, mill equipment and special machinery. *Continental Foundry & Machine Company, Chicago · Pittsburgh*

Continental Foundry & Machine Company

(FORMERLY CONTINENTAL ROLL & STEEL FOUNDRY COMPANY)

CHICAGO • PITTSBURGH

STOP—START Under full load without a sign of bearing adhesion

That's one of the most important advantages of Timken Roll Neck Bearings over other types of bearings used on mill roll necks.

Involuntary interruptions must be reckoned with in all strip mill operations. When they occur in a Timken Bearing Equipped mill it isn't necessary to relieve the roll pressure before re-starting. The mill can be re-started under normal working load because a full film of oil is not necessary between the rolling elements and raceways of the bearings.

The rolls of a Timken Bearing turn as freely and smoothly when re-starting under full load as they do at any other time. Furthermore, there is no loss of steel due to involuntary mill stoppages because the gauge remains constant at all times.

You can have these roll neck bearing benefits in your existing mills as well as in new mill equipment. Consult the mill builder or Timken engineers. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

5TH WAR LOAN

"DO MORE THAN BEFORE"

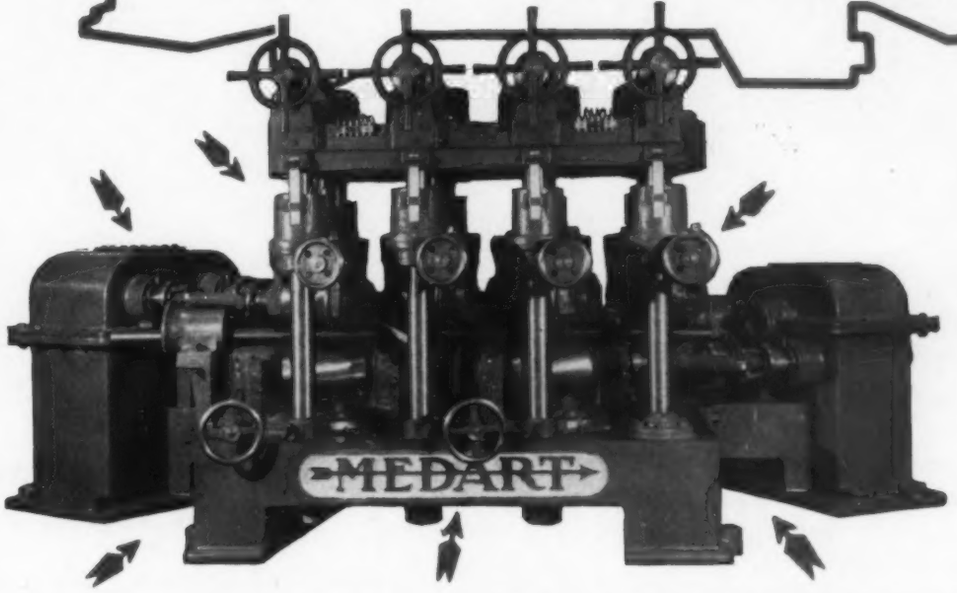
MEDART MULTICYCLE

PIPE AND TUBE STRAIGHTENING MACHINE

ALL IN ONE

Six Points of Superiority

1. **MULTICYCLE STRAIGHTENING**—Two bending rolls impose duplex straightening cycles on workpiece insuring end to end straightness.
2. **POSITIVE AND SYNCHRONIZED FEED**—All four feed rolls are driven insuring positive synchronized feed and torque balanced around neutral axis of workpiece.
3. **THE WORKPIECE LEVEL**—Maintains one feeding level for all sizes of pipes or tubes—eliminates need of adjustable entry and delivery tables.
4. **NO GUIDES**—Horizontal position of the six rolls with balanced torque eliminates requirement for guides.
5. **SINGLE MOTOR**—All four driven rolls powered from a single motor, synchronization and economy.
6. **NO BEVEL GEARS**—All gears enclosed in cases and running in oil, for sure trouble free operation.



THE MEDART MULTICYCLE STRAIGHTENING MACHINE FOR PRECISION HIGH SPEED STRAIGHTENING OF FERROUS AND NONFERROUS PIPES AND TUBES. AVAILABLE IN ALL SIZES FOR MATERIALS IN DIAMETERS OF FROM ¼" TO 18".

Manufacturing Engineers of Complete Transmission Equipment and Specialized Machinery

MEDART

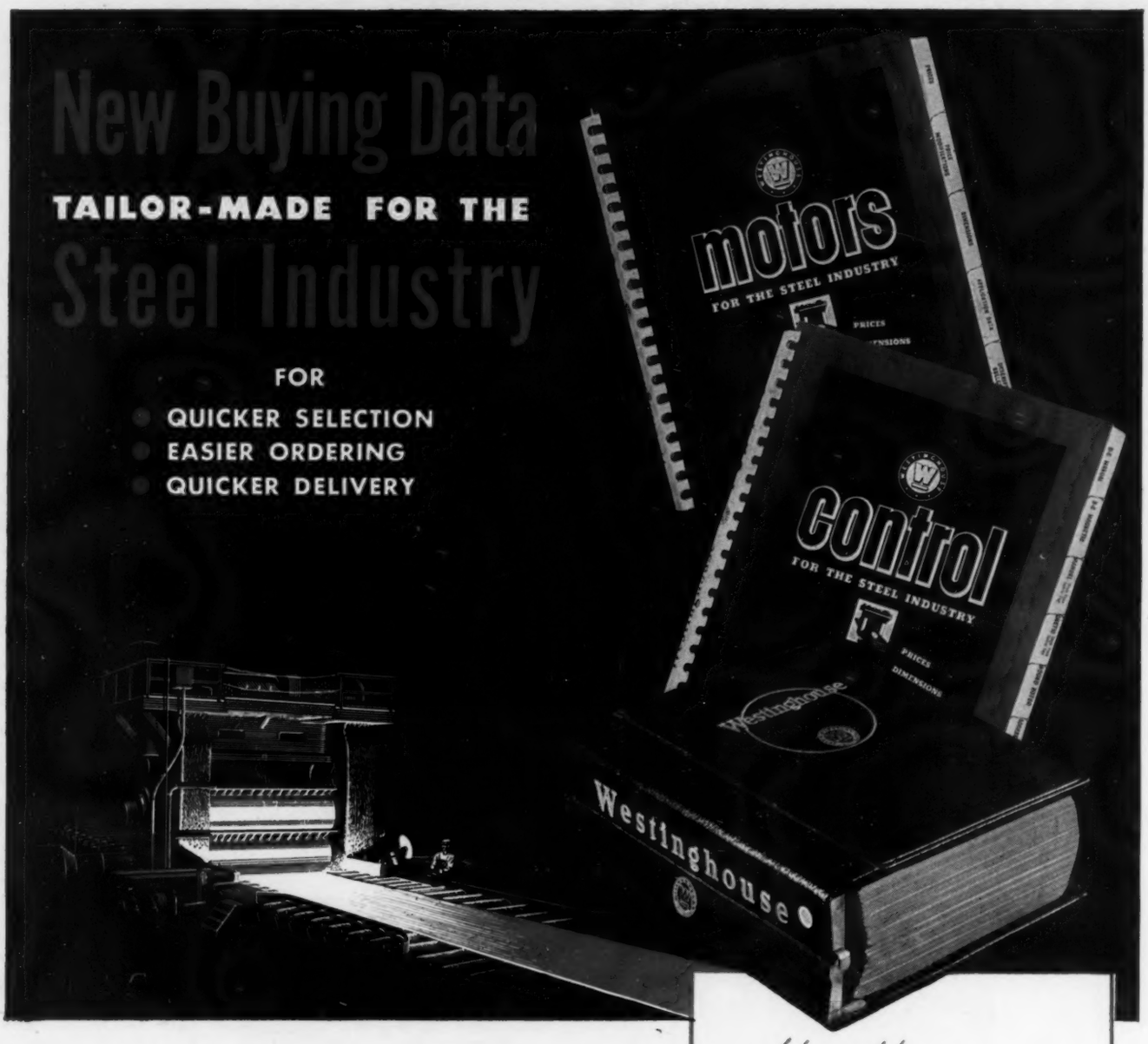
THE MEDART COMPANY
3540 DE KALB ST., ST. LOUIS, MO.

New Buying Data

TAILOR-MADE FOR THE Steel Industry

FOR

- QUICKER SELECTION
- EASIER ORDERING
- QUICKER DELIVERY



Whether it's a question of main drive motors and control or smaller drives for auxiliaries, you'll find all the pertinent facts on them *easier . . . quicker . . .* in this new, clear, easy-to-read Steel Industry Buying Data.

Data, as presented, is striking in its newness, and easier to use than any offered previously by any manufacturer. This new Buying Data is available in two forms:

PLASTIC-BOUND BOOKS — Designed for use by the majority of motor and control buyers. These catalogs contain prices for estimating purposes, plus product dimensions, application data and descriptive bulletins.

"Motors for the Steel Industry" covers popular types and ratings of motors engineered for steel industry service, Gearmotors and M-G sets.

"Control for the Steel Industry" lists a wide variety of controllers and accessories for direct-current, single-phase, squirrel-cage and wound rotor motors.

LOOSE-LEAF CATALOG—This is for the use of frequent purchasers and is "tailored" to meet the needs of the individual buyer. Pricing data is always kept up to date by the issuance of new price supplements.

J-94622

Here's How **TO GET THIS NEW BUYING DATA**

If you are a buyer of motors and control and have not received your copy, write, wire or phone your nearest Westinghouse district office (no mailings from Westinghouse Headquarters at East Pittsburgh). Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

MOTORS AND CONTROL FOR THE STEEL INDUSTRY

ONE OF A SERIES OF SUGGESTIONS TO AID PRODUCTION

ONE OF A SERIES OF SUGGESTIONS TO AID PRODUCTION

HOW TO SOLVE

Operating Problems with *Correct Lubrication*

New Grease sticks on job under this waterfall!

EVEN under the continuous pounding of this finishing stand waterfall, Socony-Vacuum's new patented grease—Gargoyle Sovarex L—sticks on its job—protects bearings from corrosion and rust.

For this new grease is specifically designed for heavy-duty steel mill service. It not only resists the washing effect of water, but it stands up under terrific shock loads and temperatures that soar as high as 450° F.

Gargoyle Grease Sovarex L is now in use in many mills, proving its exceptional qualities on their toughest grease lubrication problems. Get full details about Gargoyle Grease Sovarex L from the Socony-Vacuum representative who calls at your plant.

GARGOYLE Lubricants

SOCONY-VACUUM OIL CO., INC., Standard Oil of N. Y. Div. • White Star Div. • Lubrite Div. • Chicago Div. • White Eagle Div. • Wadhams Div. • Magnolia Petroleum Company • General Petroleum Corporation of California.

Call in Socony-Vacuum for new patented

GARGOYLE GREASE SOVAREX L

Fine records

are being made

in rebuilding

and modernizing

old coke oven batteries

. . . at great speed

. . . with minimum interruption to operations

The accompanying photograph shows one of three batteries of ovens which have recently been rebuilt at one steel plant. Similar work has been done by Koppers on many other batteries.

Ovens of modern design can be built, using a large part of the old oven steelwork, and using the old foundation pad, but with the high thermal efficiency of the modern ovens, and with the greatly improved uniformity of heating.

In these rebuilt batteries, you can get the advantage of all the mechanical improvements, including self-sealing doors, improved ascension pipes and collecting mains, with double collecting mains where their use is advantageous. In many cases existing machinery can be used with minor modifications.

If desirable, the new ovens can be so dimensioned that the coke-producing capacity will be increased over ovens that are being replaced.

Ovens not now equipped for lean gas underfiring can be rebuilt as combination ovens, thereby improving the fuel balance in the steel plant as a whole.

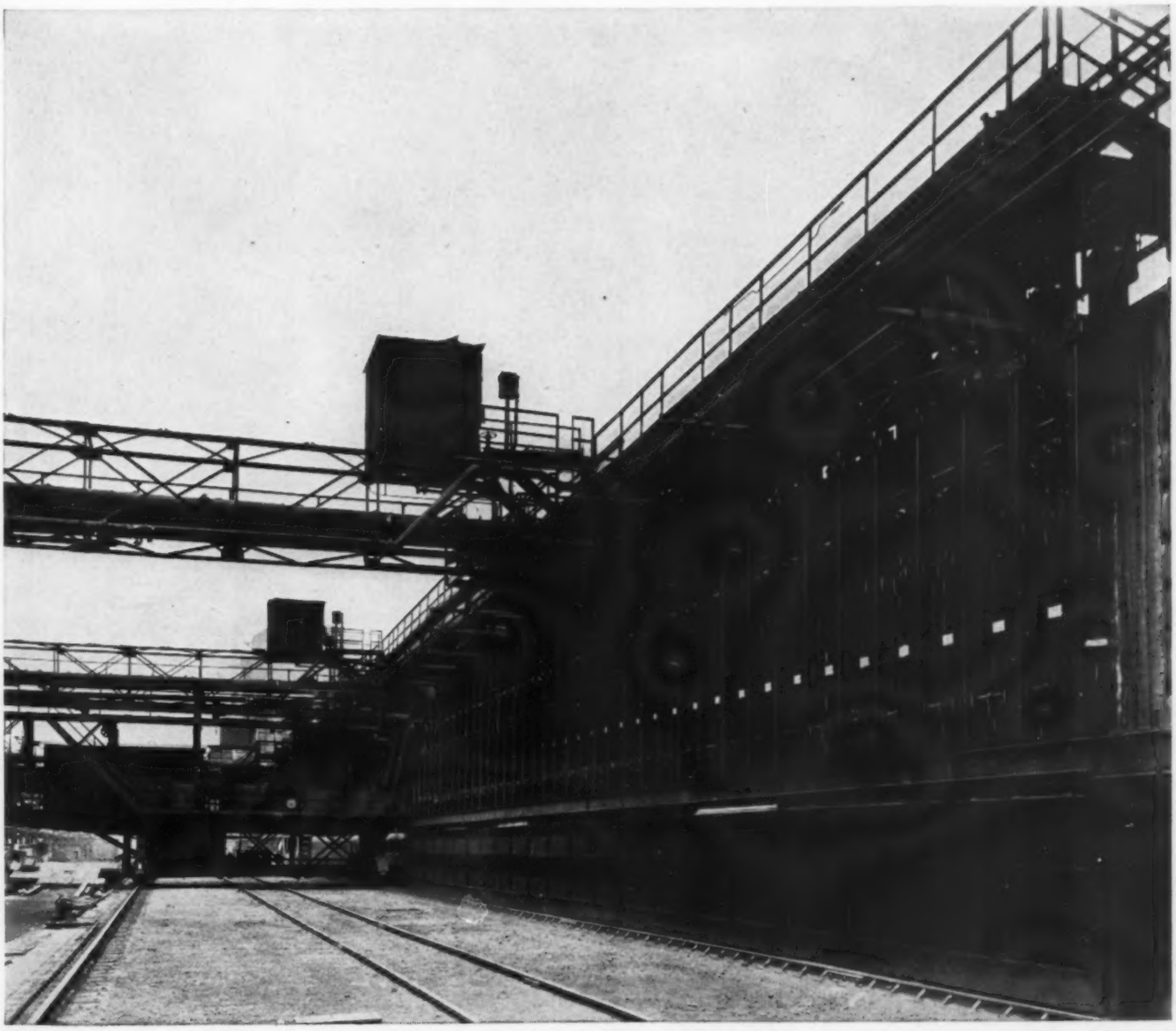
All this can be planned so that production loss is surprisingly small. Rebuilding plans should be made before old ovens have reached the end of their useful life in order to maintain orderly production schedules.

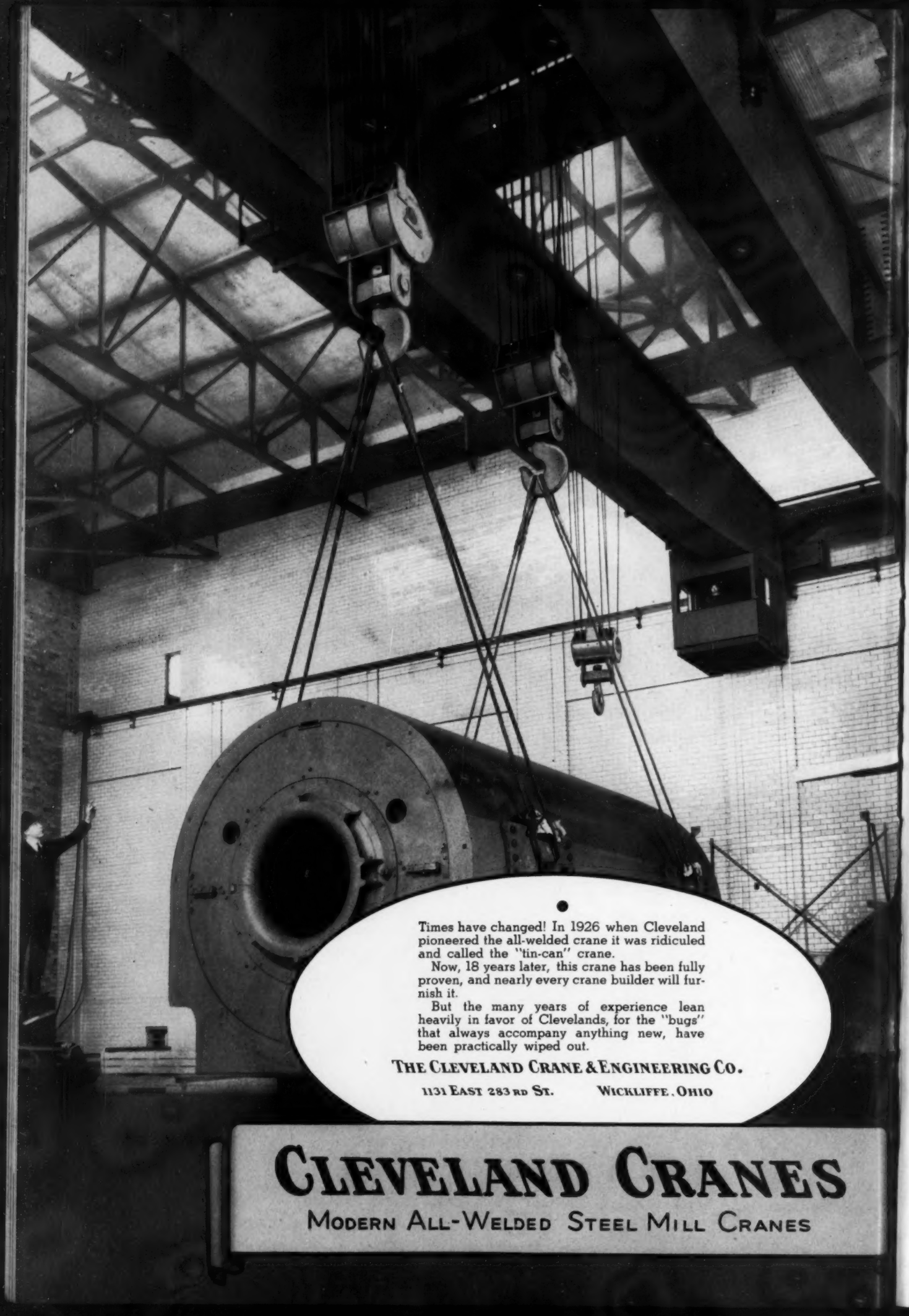
We will be glad to discuss this matter with you.

KOPPERS COMPANY
Engineering and Construction Division
Pittsburgh 19, Pa.

KOPPERS

The Industry that serves all Industry





Times have changed! In 1926 when Cleveland pioneered the all-welded crane it was ridiculed and called the "tin-can" crane.

Now, 18 years later, this crane has been fully proven, and nearly every crane builder will furnish it.

But the many years of experience lean heavily in favor of Clevelands, for the "bugs" that always accompany anything new, have been practically wiped out.

THE CLEVELAND CRANE & ENGINEERING CO.

1131 EAST 283 RD ST. WICKLIFFE, OHIO

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

Crops *and* Shorts

WITH the start of the invasion of Western Europe and the general step-up in the tempo of the war, the fruits of industry's production battle of past months come into their own true field. As ships and tanks and planes and munitions move into action, American industry can view the results of its efforts with a merited pride, confident that the tools of war which its skill has produced will be used with equal skill by the armed forces. The "stay-at-homes" have for the most part done their bit, and can look each returning fighter in the eye. For those who have hindered or shirked, who have put greed and personal ambitions before duty, let each name on the casualty lists be a finger of accusation.

▲

CERTAINLY, Maury Maverick, of Texas, should be congratulated on his one-man rebellion against the unintelligible ambiguity — "gobbldygook" is the term, we believe — of government rulings, instructions, etc. Such material, like humor and pigeons, should not be over our heads, nor should they require three readings and a legal interpretation. Let's hope that a simplification reform is really carried through.

▲

ACCORDING to a special poll of the Fortune Forum of Executive Opinion, only 37 per cent of the government war plants can be used by business after the war, and the executives further believe that the government cannot get back more than 27 cents on the dollar for its $16,000,000,000 investment in these plants. Just another indication that war isn't a good business.

▲

THE United States Department of Labor has again become excited about the loss of manpower arising from industrial accidents. The Department will, according to Secretary Perkins, award a certificate of achievement to every industrial establishment that reduces its own accident record by 40 per cent. Meanwhile, there seems to be no excitement about the fact that strikes have taken over 2,000,000 man-days out of our productive efforts during the first four months of 1944 — 45 per cent above the 1943 record. Who gets the certificate for this achievement?

▲

WAR expenditures by the United States Government now stand at approximately $300,000,000 a day, which ain't hay. And neither is the steel industry's payroll, which in its upward march hit a new high of $145,285,000 for the month of March.

MANPOWER shortages and hot weather might reduce third-quarter steel production 5 per cent under that of the second quarter, WPB's Steel Division points out in calling for all-out effort from producers. To offset this expected slump, civilian allocations for the third quarter have been cut.

▲

THE National War Labor Board has decided that management may discipline employees who go on strike in violation of a contract. The ruling was made in a case where 41 workers left their jobs because the company did not grant the union's demand that one worker in the department be discharged fundamentally because of his high rate of production. By way of consolation, we might reflect that when the 10,000,000 men return from the armed forces, they will not be thin-skinned or spoiled by pampering.

▲

A MEDAL of some sort or other should be awarded to the genius who thought up the idea of subscribing a large amount at a War Bond rally to "buy off" a visiting treasury official from delivering his speech. Could the public but thus buy off the inane commercials on the radio programs, the U. S. debt might be quickly liquidated.

▲

CONTRARY to the generally quoted statement, labor does not necessarily produce wealth. Labor does not produce wealth unless it is properly directed. If a man goes out and digs holes in the ground and fills them up again, nothing is produced — in fact, material is consumed and destroyed. Labor must produce things that people want, for which they will trade their services. And this direction is a function of management, a prerogative born in a man and not to be acquired by strikes or legislation.

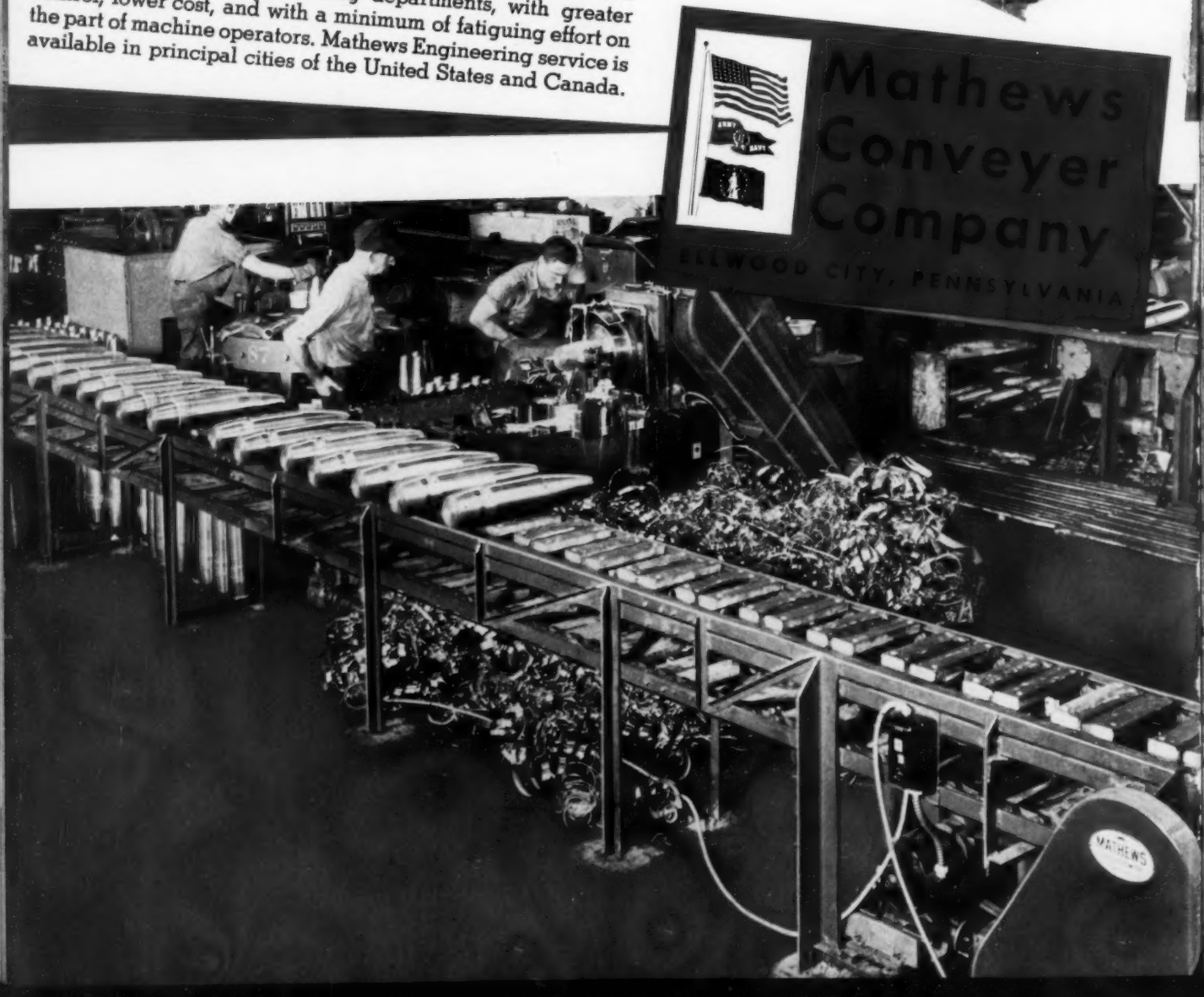
▲

EVERY engineer and technician, and every industry depending upon the services of such men, should not overlook the Kilgore bill, S-702, and the Patman bill, HR-2100, proposing to mobilize scientific and technical resources of the nation, and to establish a federal bureau for this and other purposes. No one should be misled by the idea that such mobilization sounds good for the war effort. These bills, when and if passed, will set up a bureau that will exert control over all technical personnel and activities in peacetime as well. This control will extend to all technical men who have completed any course of study in any college or university. It can extend to the mobilization of this personnel, and to the acquisition of any property, facilities, patents or knowledge of each individual, partnership, corporation or other organization useful in the development, production or supply of war or civilian goods or service. Reimbursement for the seizure of such patents, property or services is a matter to be determined solely by the bureau.

Here is bureaucracy with a vengeance — a vicious move toward the regulation of private, personal activities and prerogatives, certainly not in keeping with the principles for which we think we are fighting the present war. If you think that working under such conditions would not be to your liking, tell your senators and congressmen *now* — don't crab about it after it happens.

As Manpower Problems grow more acute.

As war production reaches its peak, the manpower situation in industry demands the use of more women and older men. More than ever, Mathews Engineering is essential. Mathews Gravity and Power Conveyers, and the special devices which make Mathews Systems prominent, are on the job in the great war plants of the United States and Canada, helping to move materials through manufacturing departments, with greater control, lower cost, and with a minimum of fatiguing effort on the part of machine operators. Mathews Engineering service is available in principal cities of the United States and Canada.



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Iron AND Steel ENGINEER

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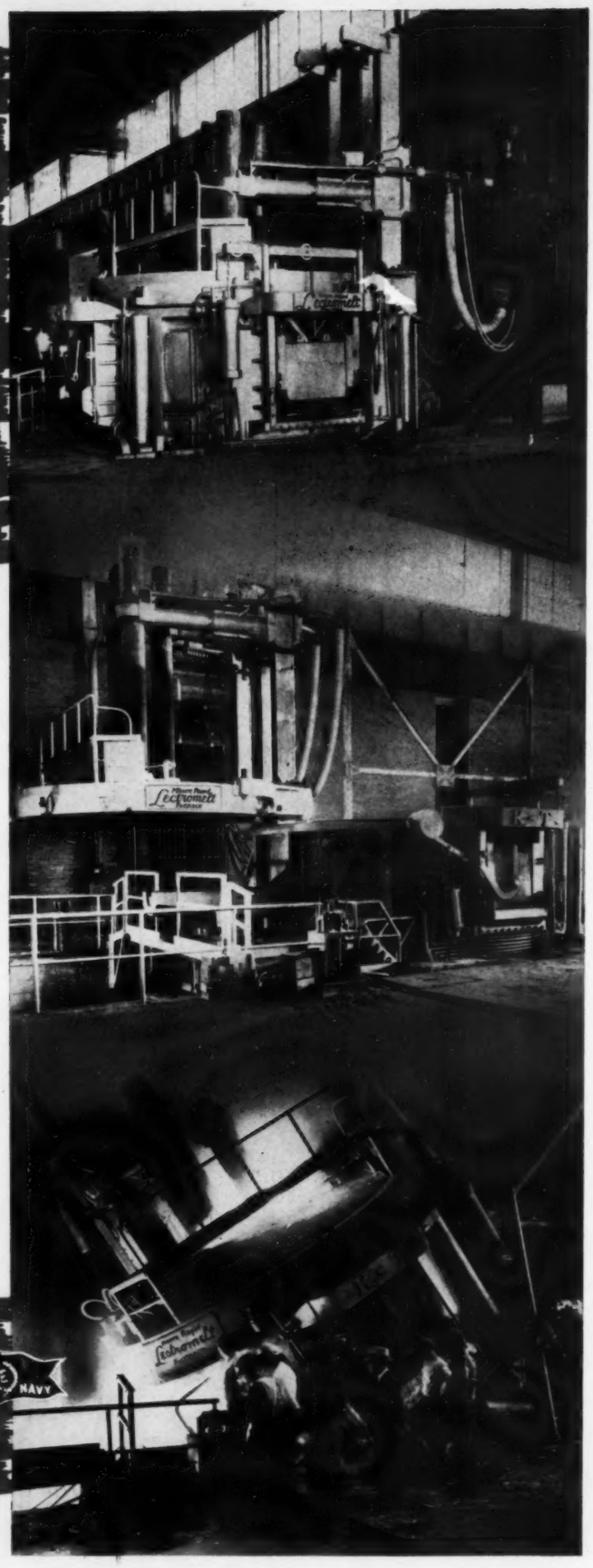
One of the Largest *Top Charge* Furnaces In the United States



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Bar AND Tube Straightening

. . . . straightening requires the neutralization or balancing of all stresses in the bar . . . . this necessitates bending in the reverse direction to a degree sufficient to exceed the elastic limit in the outer fibers . . . . the methods and equipment for straightening are discussed . . . .

by Walter Siegerist, PRESIDENT

THE MEDART COMPANY

ST. LOUIS, MISSOURI

▲ IN the consideration of this subject, perhaps the first point that should be examined is the causes of crooks, kinks, and bends in bars and tubes. The bar or tube assumes a shape in which the internal stresses are in equilibrium around the neutral axis of the cross section of the bar or tube. This gives us a key as to how to go about obtaining a straight bar or tube. It is necessary to produce a state of affairs inside the workpiece so that there are either no stresses whatever around the neutral axis of the workpiece when it is in a straight condition, or the other alternative is to set up stresses about the neutral axis so that they balance each other at all points and are parallel to each other at all points when the bar or tube is straight. A straight bar of any shape is one in which all of the stresses are parallel to a straight line and are balanced about the neutral axis passing through the center of moments. A bar may be bent because it has a contracting pull on one side and an expanding push on the opposite side. However, regardless of the cause of the bend, it is obvious that, in order to straighten a bar or tube, there is only one way to do it, and that is to bend it. The bending must be of an order great enough to neutralize or to kill the pulling tendencies of the material on the inside of the bend. Therefore, the bar or tube must be bent in the reverse direction an amount that is dictated by the elastic limit of the material. As long as the bar is bent only to stresses below the elastic limit of the material, we merely have a spring action, and it will always spring back into its original shape. However, by bending it in a direction opposite to the one in which it is bent, by a sufficient amount to exceed the elastic limit in the outer fibers of the cross section, the bend will be corrected.

Figure 1 shows what might be termed bending methods in the early American scene. They are still termed hand straightening methods. The original method used exactly the process that has just been outlined. A portion of the bar is placed between the jaws of a vise or some other holding device, and the end of the bar is sprung up towards the bend and beyond a sufficient amount to correct the bend. This operation can be compared to the action that is imposed on a beam fixed at one end and loaded at the opposite end. The bending moment in such a case is $M = P \times L$. P is the load or force that is exerted, and L is the length of the beam from the point where it is fastened out to the end point where the load is applied.

The more refined present-day method of hand straightening is termed gag straightening. This is familiar to everyone and is accomplished by having two supports such as A and B with a moving head C for applying the load. The load is applied either mechanically through a fly wheel and a train of gears with a plunger that moves up and down, or by straight hydraulic application.

The action in this case is represented by the simple beam supported at both ends with the load application at the mid point. The bending moment formula in this case is $M = PL/4$.

The third method of hand straightening is still very much in use on the farm. It is the stretching method.

Presented before A. I. S. E. Pittsburgh District Section Meeting, March 13, 1944.

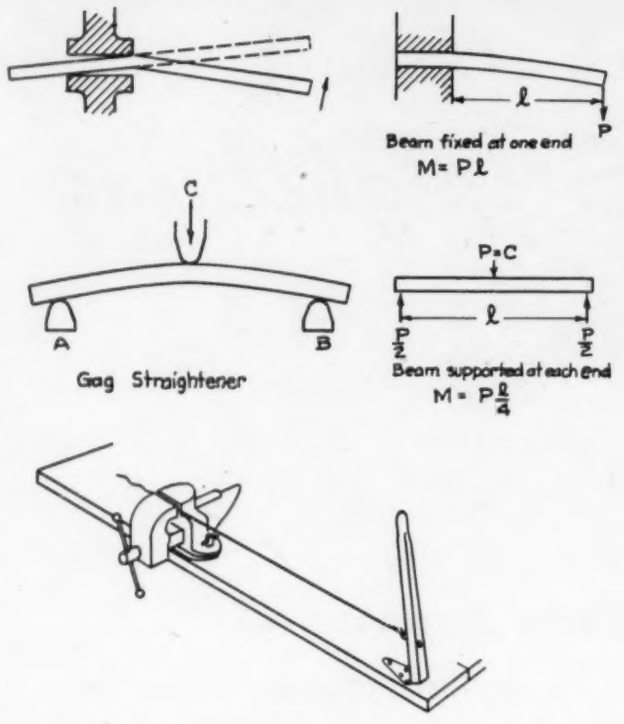


Figure 1 — Hand straightening methods.

▲

Figure 3 — Non-rotating machine straightening methods.

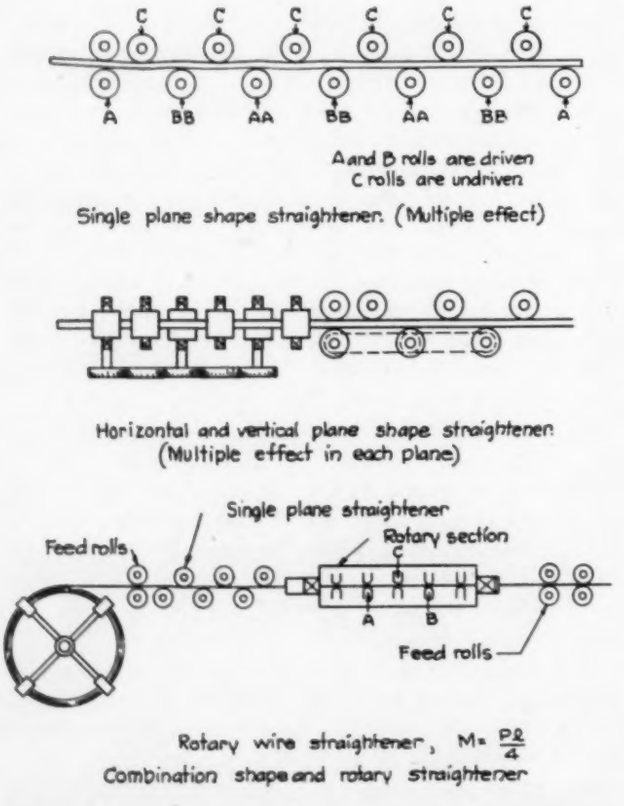

C C C C C C
A BB AA BB AA BB A
A and B rolls are driven
C rolls are undriven
Single plane shape straightener. (Multiple effect)
Horizontal and vertical plane shape straightener
(Multiple effect in each plane)
Single plane straightener
Rotary section
Feed rolls
Feed rolls
Rotary wire straightener, M = Pℓ/4
Combination shape and rotary straightener

Figure 2 — Hydraulically controlled percentage stretcher leveler.

A wire is gripped between the vise jaws and by means of a lever at the other end, a man can give it a yank which will straighten it.

Figure 2 shows a modern version of the stretching method of straightening materials. This is a hydraulically controlled percentage stretcher leveler machine used for correcting the edge camber and final leveling of such items as aluminum in coils. The same method is used for straightening certain formed shapes. This particular machine is arranged to straighten the aluminum from the coil, and then immediately recoil it. The operation consists of gripping a 40 or 50 ft length between the jaws, then the stretching procedure starts automatically. At a pre-determined resistance when all slack has been removed, the percentage control goes into action and after the desired percentage stretch has been imposed, the grip jaws are automatically released. The material is then recoiled until the stretched portion has been pulled through the machine and another length is then put through the same process until the entire roll has been straightened and leveled.

The various non-rotating machine straightening methods are shown in outline in Figure 3. The ordinary shape straightener of the single plane variety has from 8 to 14 rolls. The functions of the various rolls are indicated by the letters A, C, and B. The C rolls are idlers and are adjustable for imposing the load on the bar. Wherever the letters are doubled, it is an indication that the reaction is doubled. It will be noted that we here have a continuous beam action very similar to the action in the gag straightening method. When the roll combination is duplicated and turned to 90 degrees, we have the familiar horizontal and vertical plane shape straightener. Thus we obtain a multiple effect in each plane. The designation, shape straightener, is very descriptive of the type of work in which these machines are most effective. In view of the fact that they exert their pressure in only one plane, it can readily be understood that a round bar or a round tube would have a tendency to dodge the straightening action by twisting under each of the rolls C and over the others. There are no flat faces or corners or edges to make a round bar and a round tube stay in position, and consequently

this nonrotating straightening machine is not so effective on round cross sections. The lower machine shown in Figure 3 represents the combination of a single plane straightener and a duplicate of the single plane straightener mounted in a rotating section. This is the familiar rotary wire straightener. Here again A and B are the supporting points and C is the loading point so that the bending moment that is imposed is PL/4. However, the rotary section causes this to be imposed around the 360 degrees of the workpiece instead of only in two planes at 90 degrees to each other. This rotating bending moment action is evidenced in the so-called "roping" of the wire. We will again meet up with this action in one of the later machines.

Figure 4 shows a hexagon, flat, and square shape straightener viewed from the input end. The grooves that are visible in the feeding pinch rolls are for the hexagon shaped bars. The flat section below the grooves is used for squares and flats. This machine differs from many of the shape straighteners on the market today in that the rolls are inboard mounted; that is to say, they have a bearing at each end. It is not necessary to change the rolls in this machine in going from hexagons to squares or flats because the input section can be dropped so that the hexagon grooves will line up with the second plane thereby making it unnecessary to change rolls. Figure 5 shows the same machine from the output end. It will be seen that there are no grooves in the rolls in this case. The part standing at the left of the illustration is the base of the input side. This shows the four threaded columns that support the input side and permit raising and lowering when changing from hexagon to flat and squares or vice versa. This machine will straighten shapes at a throughput speed of 250 to 600 feet per minute with either steel or nonferrous material. The inboard mounting of the rolls overcomes any tendency toward deflection that might occur in the cantilever type or outboard mounting. This is very important when critical or exact straightening is required because it insures uniform deflection of the workpiece over its entire width.

Figure 6 shows two types of early rotary bar and tube straighteners. The design shown at the top of the figure consisted of a rotating frame in which were mounted six rolls. The frame was rotated around the workpiece held by grip tongs carried on a carriage. The rolls were all concave so that, as the frame rotated, the angularity of the concave rolls forced the bar through the flyer. This machine imposed a multiple number of straightening cycles on the workpiece as indicated by the diagram. The reaction at B and C was double that at A. The other roll combination shown in Figure 6 is perhaps the earliest rotary straightener that was used on bars. It consisted of twin rolls A that were driven. The load was imposed on roll C that was not driven. B was a rest or polisher through which the workpiece was forced. Generally babbitt metal or wood or some other material was placed in B so that the workpiece would come out in a polished condition. Both of these machines still use the simple bending moment principle of $M = PL/4$.

Figure 7 (top) shows a modern rotary arrangement making use of the bending moment $M = PL/4$. In this case A and B become a pair of rolls, one of each of which is driven through a driving shaft and a set of

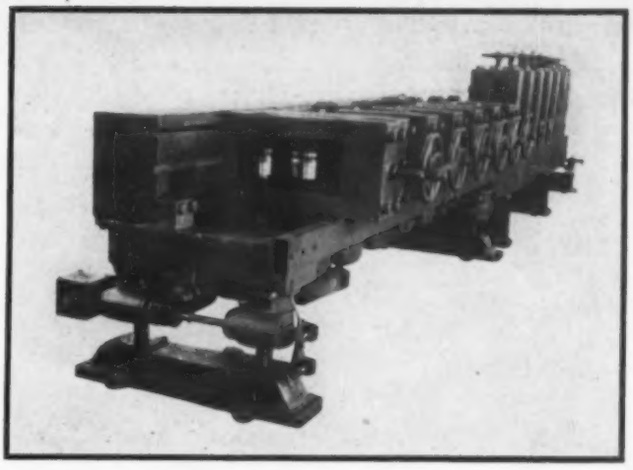
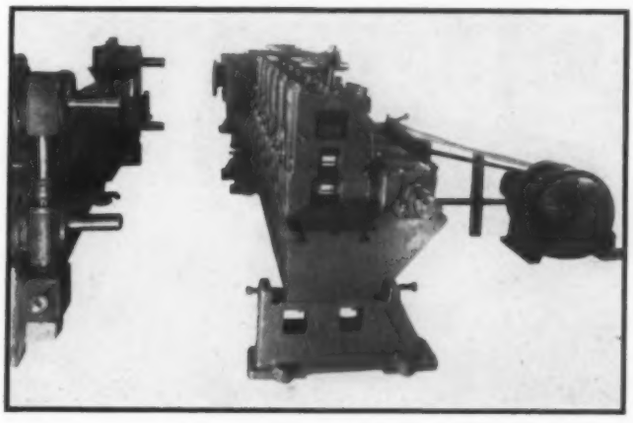


Figure 4 — Straightener for hexagon, flat and square shapes (entry end).

▲

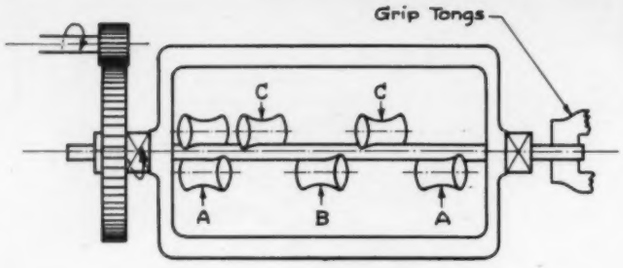
Figure 5 — View of exit and of the straightener shown in Figure 4. To the left is shown the base of the machine.



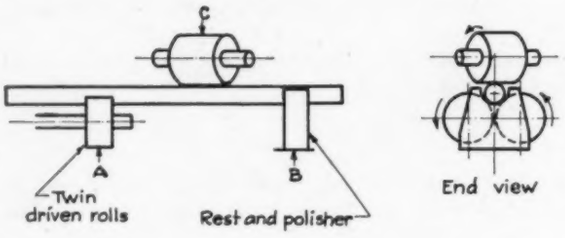
bevel gears. C is the idler or bending roll that imposes the straightening load. It is a five-roll single cycle type and, in most applications, there is a bottom guide used between A and B to properly position the workpiece opposite the idler C. The other machine, bottom of Figure 7, is a straightener of the six-roll type. Here again the bending moment is the same as in the conventional simple beam, but in this case, all feed rolls, both top and bottom, are driven, and there is a true idler roll under the bending roll, thereby eliminating the necessity of having a guide in this machine. Figure 8 shows one of the modern five-roll straighteners.

Figure 9 in the upper portion shows a two-roll straightening, sizing, and polishing principle. It is a multiple cycle principle. An examination of the workpiece between the concave roll and the modified straight roll indicates that the loading is as shown on the uniformly loaded beam shown at the right hand side opposite the combination of rolls and workpiece. Here the reactions at each end are replaced by the familiar formula $WL/2$ so that the maximum bending moment now becomes $WL^2/8$.

One characteristic of the five-roll and six-roll types of machines is that the angle between the roll axis and

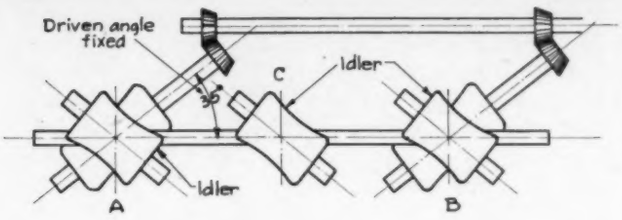


Brightman Flyer (Multicycle) $M = \frac{Pl}{4}$



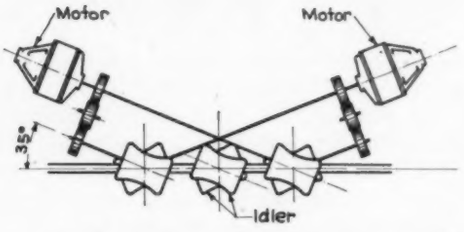
Rotary straightener (Single cycle) $M = \frac{Pl}{4}$

Figure 6 — Rotary bar and tube straighteners.



5 Roll - Abramsen - Sutton Straightener $M = \frac{Pl}{4}$
(Single cycle) (Bottom guide)

Fig. 7



Six Roll "Abramsen" Straightener $M = \frac{Pl}{4}$
McIntosh - Abramsen
(Single cycle) (No guide)

Figure 7 — Rotating single-cycle straighteners of five and six rolls.

the workpiece generally is about 35 degrees. In the two-roll machine of Figure 9, this has been dropped to the average position of 17 degrees. The angularity of the rolls is now adjustable in practically all rotary straightening machines. It is to be particularly noted that the two-roll type of straightening machine shown in Figure 9 uses a top and bottom guide to properly position the workpiece between the modified straight and the concave rolls.

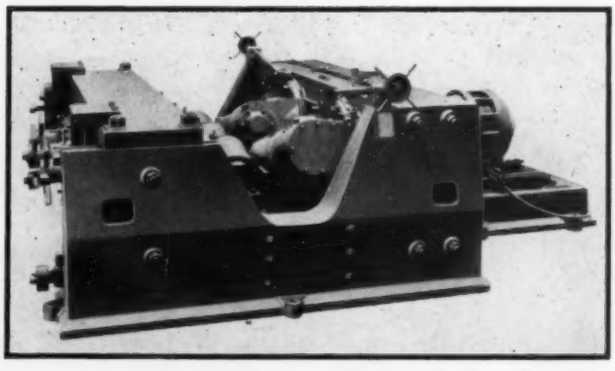
This is the only rotary straightening method in which the workpiece is subjected to a continuous straightening action from the point of entrance between the work rolls to the very end of the path as the workpiece leaves the rolls. Therefore, these machines are all multiple cycle machines in which the number of cycles to which the workpiece is subjected is equal to the length of the path L divided by the circumference of the bar or tube times the tangent of 17 degrees. The denominator of the fraction happens to work out so that it is a constant of approximately .96 times the diameter of the workpiece so that for rough and ready reference the operator can divide the length of the contact path in the rolls by the diameter of the workpiece, and thereby get the number of straightening cycles that each cross section of the workpiece is subjected to in each pass through the machine. This applies only to two-roll straightening, sizing, and polishing machines of the type shown in Figure 9. The number of cycles increases as L increases and as the roll angle decreases.

A three-roll straightener principle is also shown in Figure 9. Here again, we have the familiar pattern of A and B as the support points and C the application of the bending or straightening load. The formula again is $M = PL/4$. This machine consists of two short rolls in one plane with parallel shafts, both driven. The straightening roll is above these and crosses them and is also driven.

Figure 10 shows a two-roll straightener with the workpiece and the guides in position. The right hand roll is the modified straight roll and the left hand roll is the concave roll against which the workpiece is bent. Straightening speeds vary from 20 to 200 fpm. Generally the range is from 30 to 150 fpm.

Figure 11 shows a two-roll straightening machine of the size used regularly for the bar diameters from $\frac{1}{8}$ in. to 1 in. inclusive. It has been used for material of $\frac{1}{16}$ in. diameter, but it is not recommended for diameters as small as this. This machine was especially designed for very accurate adjustment. You will note

Figure 8 — A modern five-roll straightener.



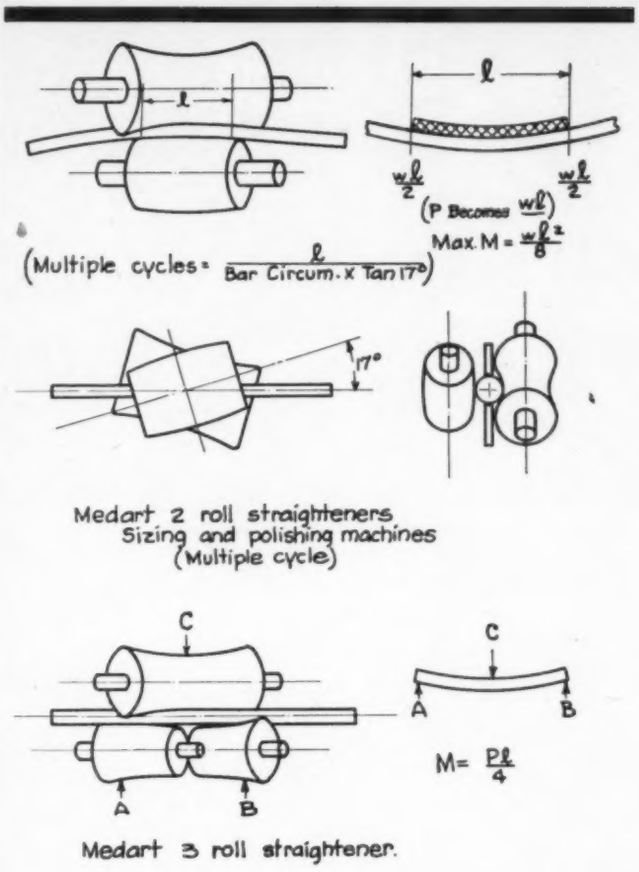


Figure 9 — Rotating two- and three-roll straighteners.

that the indicator for the angularity of the rolls is extended above the roll housing. It can be read directly to $^1/_{10}$ of a degree. Likewise, the straight roll can be locked into position after the proper setting has been obtained so that there is absolutely no play in the housing. The rolls are always mounted in preloaded matched roller bearings so that there is no bearing lash whatever. Machines of this size are used for straightening such items as chain pins of $^3/_{32}$ in. diameter by 2 in. long. Some of the chain pins for quadruple chains are 12 and 14 in. long. All of them are straightened after hardening to a precision straightness that is within .001 over the entire length.

Figure 12 shows the largest machine of this type ever built. It will straighten bars in the diameter range from 1 in. to 9 in. inclusive, the material having an ultimate tensile strength of 125,000 pounds. The bearing capacity of this straightener is 850,000 pounds with a factor of safety of 5. This is the measure of the straightening power and also the cold sizing ability of the machine. One of these machines is used for cold rolling and straightening aluminum billets in the Reynolds Alloy Company. Figure 13 shows the same machine from the output side. The hollow shaft is the exit or output point of the straightened bar or tube. The hand wheel at the side of the gear case is used to shift the gears from high to low speed. All machines manufactured by the writer's company are equipped with two speed changes in the gear case in order to permit the use of a-c motors if necessary.

Figure 14 shows the newest type of two-roll straightening, sizing, and polishing machine. This is a machine for bar sizes ranging from $^3/_4$ in. to $4^1/_2$ in. inclusive. The rolls are of exactly the same shape as used in the two roll single motor type of machine, but each roll is driven by its own motor. Figure 15 is a view from the input side of the machine. The two spoked hand wheels that are noticeable in Figure 15 are used to change the angularity of the rolls. Bar throughput speeds of 1000 fpm can be used for restraightening work.

The three-roll straightening machine shown in Figure 16 is driven by one motor and has two gear boxes, one

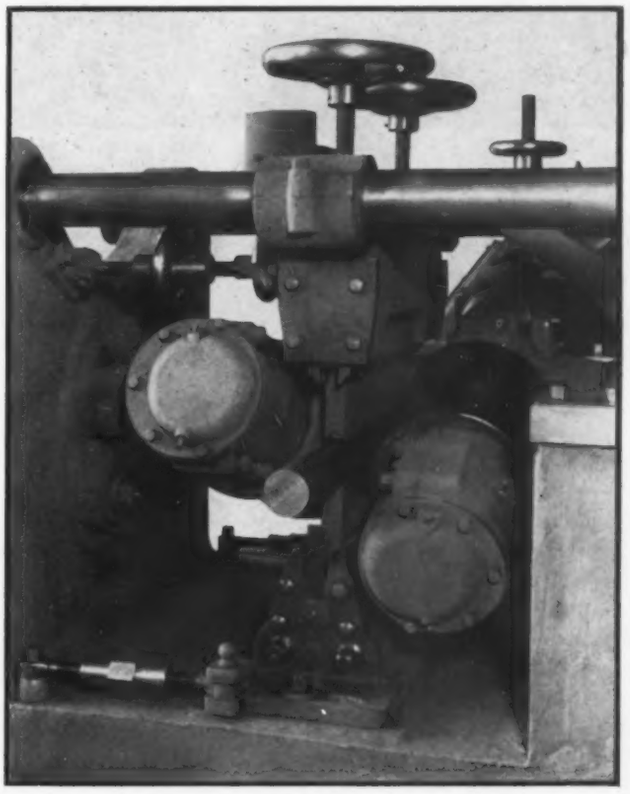


Figure 10 — Two-roll straightener with workpiece and guides in position.

▲

Figure 11 — Two-roll straightening machine for bar diameters of $^1/_8$ in. to 1 in. inclusive.

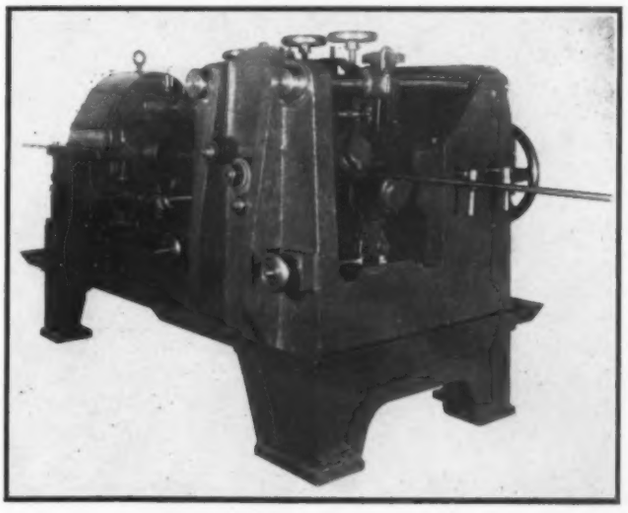


Figure 12 — This two-roll straightener, taking bar diameters from 1 in. to 9 in. inclusive, is the largest machine of this type ever built.

Figure 13 — View from output side of the large machine shown in Figure 12.

of them driving the upper roll, and the other one driving the two lower twin rolls. Figure 17 clearly shows the action of this machine. The workpiece is supported at points A and B of the conventional beam with the load application at the middle. This machine is particularly well suited for tubular work such as welded pipe where the cross section may vary somewhat. The straightening is accomplished without the application of any load directly across the diameter of the workpiece at any point; consequently, it permits a variation in diameter without a crushing or ringing action that sometimes is so troublesome.

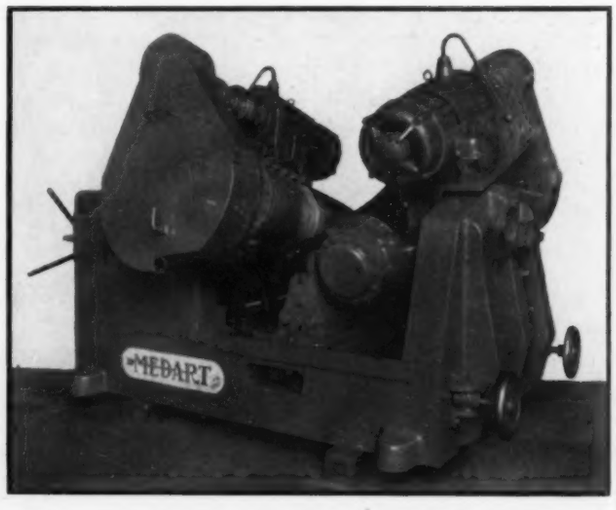
Figure 18 (top) is an arrangement of the earliest six-roll straighteners. It consists of a pair of rounded rolls set at an angle to each other on a frame, then another pair mounted on another frame, and the two frames in turn mounted on a four wheel carriage. The bending moment was imposed by a pair of rounded rolls with their axes parallel to each other. These were adjustable. The workpiece was rotated by means of a grip turned by a pulley. The turning of the grip turned the bar which, in turn, caused the rolls to rotate, and their angularity made the straightening mechanism move out to the end of the bar, and then by reversing the rotation, it would move back again. Figure 19, taken from an old catalog, illustrates this particular straightener.

Figure 18 (bottom) shows the latest rotary multicycle six-roll straightener. It differs from other six-roll straighteners in that the sixth roll is also a straightening roll, and all four driven rolls are driven by one motor. Each of the feed rolls is driven. The arrangement of the six rolls clearly shows that this is a two cycle straightener imposing the straightening action in the manner of a continuous beam, and as in the case of the old flyer, the straightening load at the second cycle is 1½ times that imposed by the first cycle when the applied loads on the two bending rolls are equal. This, of course, means that a greater straightening action can be obtained with the same roll bearing load in the straightening rolls as compared to a standard five-roll machine.

Figure 20 shows the latest model multicycle six-roll straightening machine, particularly designed for the straightening of all solid round sections, and tubing in all wall thicknesses. The reason for mentioning tubing in all wall thicknesses will be apparent by later remarks particularly with reference to thin wall tubing. The figure shows the machine from the operator's side. The workpiece moves from left to right. The funnel guide is merely a target for the operator to shoot at when entering the tube or bar into the machine. Obviously with the top and bottom guide rolls driven, there is no necessity for guiding the workpiece if it is properly entered into the machine. However, it is very important that the workpiece be entered in the proper direction and at the correct point between the two feed rolls.

Figure 21 shows the multicycle straightener looking at it on the discharging side. This view also indicates the multiple V-drive for attaching the single motor and the two speed gear box through which the machine is

Figure 14 — Late design of two-roll straightening, sizing and polishing machine, taking bar diameters of ¾-4½ in.



driven. It is also well to note that there are six hand wheels for adjusting the angularity of the six rolls; likewise, each top roll is adjusted by its own spoked hand wheel at the top of the machine. These spoked hand wheels have micrometer divisions for close setting. The rough setting of each roll is obtained by direct reading on the individual steel gages shown at the four top crossheads.

A rear view of the multicycle straightener is shown in Figure 22. The workpiece moves from the right to the left of the illustration. The inclined straight roll guide is clearly visible in this picture. There is a duplicate of this on the opposite side. The purpose of these two inclined roll guides is to correct any misalignment that may exist in the entering workpiece, or if the end of it is badly bent, they will keep the end in line so that it will enter properly between the output feed rolls. This photograph also gives an excellent illustration of the action of the sixth or second cycle straightening roll. It demonstrates clearly how this roll may be used to double up on the effect of the first roll or to treat the workpiece less harshly in the second effect.

Another very important point that should be noted is that this arrangement of the six rolls gives absolute symmetrical straightening and gives the full effect at each end because that portion of the tube that has not received any straightening action by the first straightening roll does receive it as it comes under the second straightening roll. Thus, the effect of this six-roll straightener is equivalent to passing the workpiece through a standard five-roll straightener two times, and reversing it end for end between passes.

The multicycle straightener is particularly adaptable to thin wall tubing work when the action of the feed rolls is analyzed. Figure 23 shows the action of the machine with only one driven feed roll as compared to the machine with the two driven feed rolls in each pair. The force F indicates the torque action of the driven feed roll. In those machines where only one of each pair of feed rolls is driven, it will be noted that this torque is applied in such a way that it has a twisting arm equal to the diameter of the workpiece because the torque F is applied on the side opposite to the one to which the bending or straightening action is applied. The diagram shows the application of the straightening effort in both the vertical and the horizontal planes. When the reaction is studied in the horizontal plane, it will be easily understood that there is a tendency to deflect the workpiece away from the application of the straightening load C. The measure of intensity of this force is the torque effort F times the diameter of the workpiece

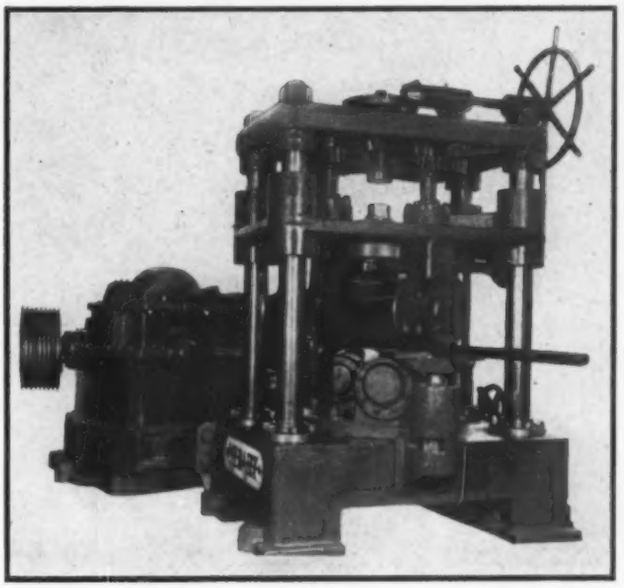
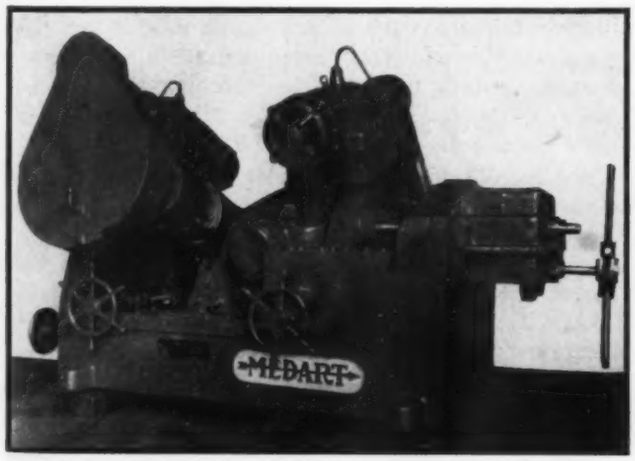


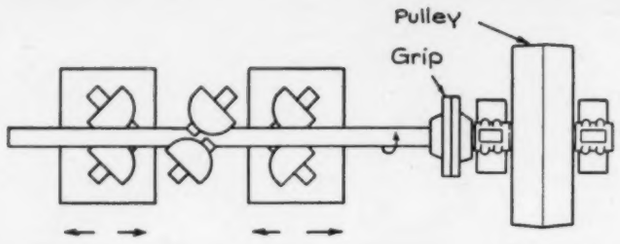
Figure 16 — Three-roll straightener driven by one motor through two gear boxes.

▲

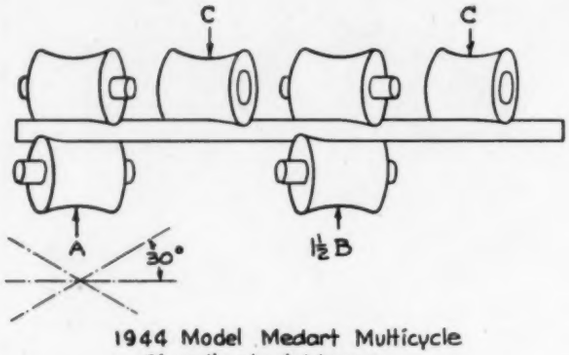
Figure 17 — Closeup of rolls in the three-roll machine of Figure 16, showing the action of the machine.

Figure 15 — View of the machine shown in Figure 14, taken from input end.





Early Medart 6 roll straightener
(Single cycle)

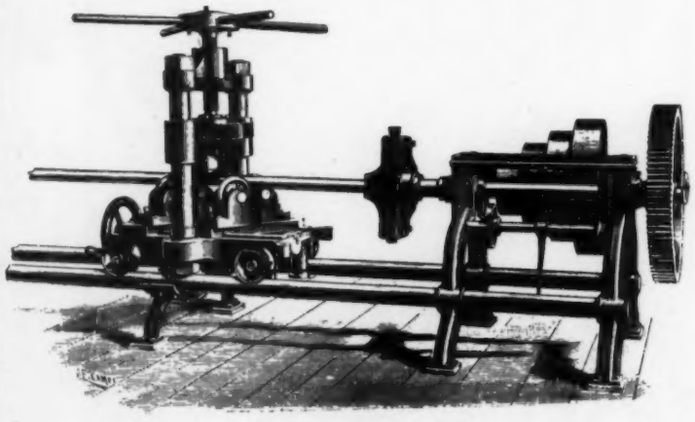


1944 Model Medart Multicycle
Six roll straightener
(Two cycle with continuous beam action)

Figure 18 — Early and recent designs of six-roll straightener.

▲

Figure 19 — Old catalog cut of early six-roll machine of the design shown at top of Figure 18.



D, and is also effected by the length of the span L. It is this reaction that requires a bottom guide in the conventional five-roll straightener.

Now let us consider any straightener in which both rolls that do the feeding are driven, and this discussion will apply to the two-roll types of machine as well as the six-roll (if the two motors are synchronized). We will assume that identical tubes or bars are passed through each type of machine, therefore, exactly the same torque would be required to force the workpiece through the machine. If this is true, then the synchronized two driven rolls in the pair will exert the torque force F/2 at opposite ends of the diameter of the workpiece. This results in the same turning torque, but we now have a balanced condition about the neutral axis or centerline of the workpiece. This balanced condition continues throughout the workpiece because the second pair of feed rolls is driven in the same manner, consequently, even though there may be a twisting of the workpiece, the balanced condition exists nevertheless, and there is no tendency for the workpiece to be deflected because of the application of the bending or straightening force at C. This is readily evident by studying the analysis of the forces in the vertical plane, and also in the horizontal plane. This balanced condition explains why it is not necessary to have guides in six-roll machines when all feed rolls are driven and synchronized.

The importance of this fact is quickly evident when it is considered in connection with thin wall tubing. The twisting torque for a thin wall tube in a conventional five-roll machine with only two rolls driven is doubled up insofar as concentration is concerned. In other words, the pivoting point is at the opposite end of the diameter, therefore, if we assume that a force F great enough to put a permanent twist in the tube is applied by the single driven roll, then we will obtain twice the turning torque in the six-roll machine with no greater fiber stress. The importance of this lies in the fact that the five-roll single cycle straightening action can be accomplished with less roll pressure in the six-roll machine, or double the straightening action may be obtained with the same roll pressure. However, multiplied straightening action can be obtained only in the multicyclic six-roll machine.

Heretofore, the limitations for straightening tubes by the rotary methods have always been either the point where the tube would be twisted due to the reaction of the straightening load at C, or the roll pressure necessary to impose the torque when a single driven roll is used would crush the tube wall so that a spiral would be rolled into it thereby ruining the tube.

The invention of the single motor synchronized six-roll multicycle straightening machine has widened the field for rotary straightening of tubular products so that there is now practically no limit in any direction, whether it be the ratio of diameter over wall thickness, minimum diameter, maximum diameter, speed, and so on, all of which formerly were definite limitations to successful rotary machine straightening applications. The straightening speeds can be set at 300 fpm or higher if desired.

All two roll straightening, sizing, and polishing machines made by the writer's company have sizing and polishing characteristics as well as straightening characteristics. The polishing characteristic is an inherent characteristic of these machines because the workpiece is flexed between two rolls, one of which is concave and the other one is a modified straight roll, and therefore there is a differential in surface speed over the path of contact due to the fact that the ends of the concave roll naturally have a larger circumference than the mid

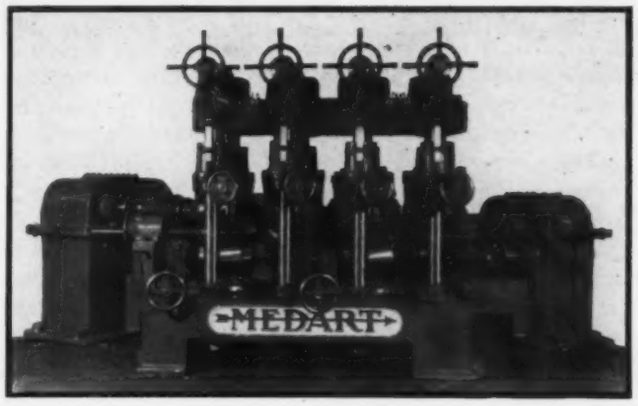
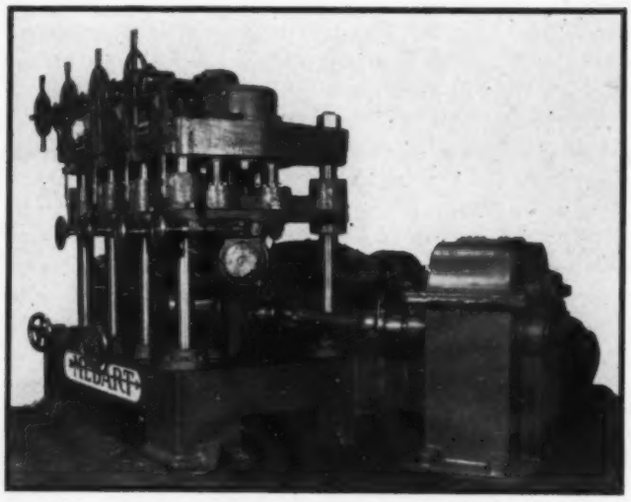


Figure 20 — Late model of six-roll multicycle straightening machine.

▲

Figure 21 — Another view, from the exit side, of the straightener in Figure 20.



section. The workpiece has a uniform cross section; therefore, there is always some slippage between the surface of the workpiece and the surface of the concave roll. This can be accented still further by creating a differential between the straight roll feeding angle and the concave roll feeding angle. However, too much differential may have the unhappy effect of appearing in a spiral or barber pole stripe on the workpiece.

The sizing of solid bars requires very high roll pressures. Consequently, if it is desired to use the two-roll straightening machine for precision sizing work, it is recommended that, regardless of the diameter to be sized, the machine should be designed for a maximum bar diameter of 3½ in. However, a really good sizing experience starts with a larger unit where the safe roll bearing load, with a factor of safety of 5, amounts to 260,000 pounds. This machine really corrects out of roundness and if the material will permit it, will reduce the diameter.

The sizing of tubes is accomplished much more easily. However, there are two characteristics that must be kept in mind, particularly the one with reference to the length of the tube. A two-roll rotary straightening machine will very decidedly shorten the tube length. This occurs even though the tube diameter might be

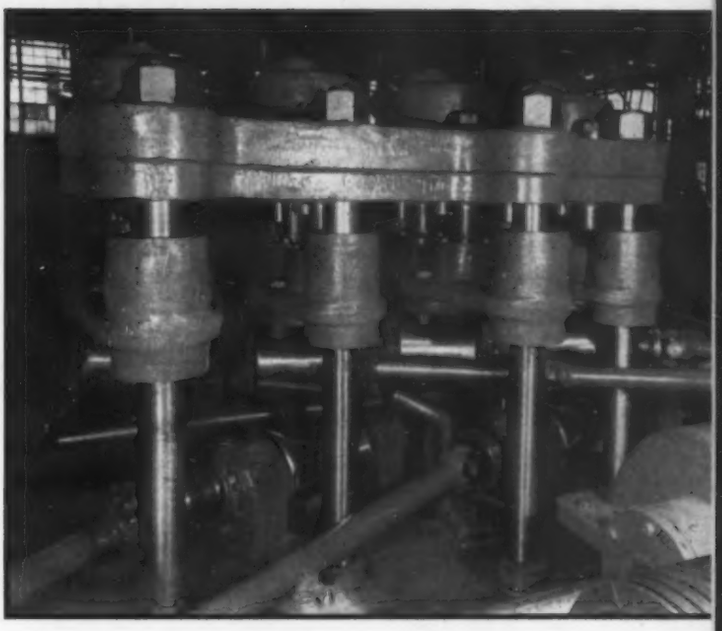
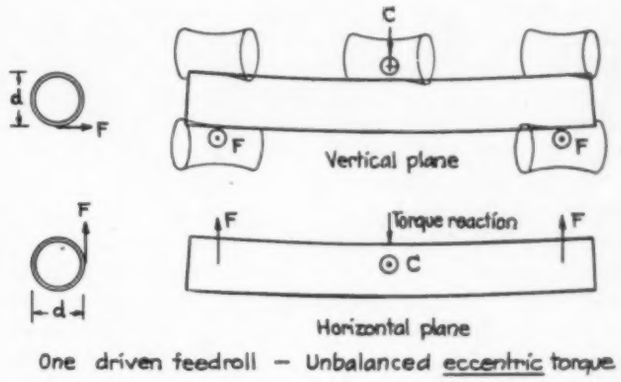


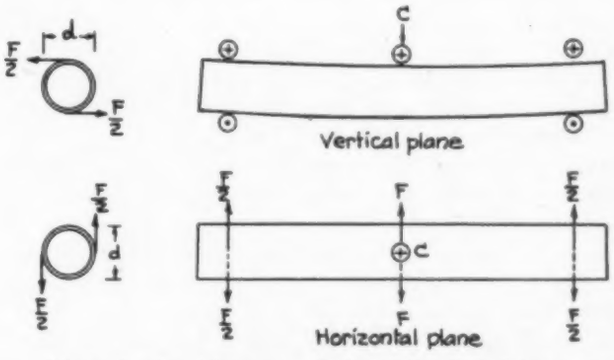
Figure 22 — Closeup view of the six-roll machine of Figure 20.

▲

Figure 23 — Sketch showing the comparative action of machines with one driven feed roll and with all feed rolls driven.



One driven feedroll — Unbalanced eccentric torque



All feed rolls driven — Balanced concentric torque

increased to a slight extent. An example of this is the derodding operation where the tubes are drawn over a rod or mandrel, and then removed by putting them through a two-roll machine. The decrease in length is transferred to an increase in wall thickness. The two-roll machines will successfully straighten and size tubular products in which the ratio of diameter to wall thickness, as a general rule, is 30:1 or less. If the hot rolling or hot finishing of the products, either tubes or bars, has been carefully done, the cold sizing on the straightener will produce products well within the tolerances of ordinary cold drawn products.

DISCUSSION

PRESENTED BY

H. G. R. BENNETT, Engineer Hot Rolling Mills, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania

WALTER SIEGERIST, President, The Medart Company, St. Louis, Missouri

H. M. BRIGHTMAN, Chief Engineer, Columbia Steel and Shafting Company, Pittsburgh, Pennsylvania

H. G. R. Bennett: If the two-roll straightening machine was performing satisfactorily, I would like to know why they went to a multiple-roll machine?

Walter Siegerist: The two-roll machine has definite limitations. The two-roll machine is not successful for tube straightening if the ratio of diameter of a tube over the wall thickness exceeds 30:1. The crushing strength of a very thin wall tube over the short length of the span in a two-roll straightener is such that the tube will crush before it will bend. As the diameter of the material to be straightened increases, you must increase the length of the span. When you have more than a 30:1 ratio you must go to a multiple roll machine to get a longer beam span. As far as a bar or heavy wall tube is concerned, the two-roll machine will do the best job, because you give each cross section a multiple number of cycles depending on the relation of span to the workpiece. With a two-roll machine it is as much as eight, and from there on it continues to multiply and only a two-roll machine will straighten absolutely from end to end.

H. M. Brightman: I have enjoyed Mr. Siegerist's paper very much, and particularly his tribute to the old pioneers in the straightening field. Mr. Siegerist has shown in one of his illustrations, several methods, demonstrating the fundamental principles of straightening for the record. The one known as cantilever method of straightening was patented and developed by Wm. McCool of Beaver Falls, Pennsylvania, starting during 1889 and is still being used today.

Mr. Siegerist spoke of the bending moment $WL^2/8$. When rolls are alternately spaced, such as in some of the older type of straighteners, we used $WL/4$, because we were more interested in the stress at the center. The bar was figured as a free beam, supported at both ends and loaded at the center. Knowing the loading of the bar at the center we could figure the deflection required for straightening, thus keeping the deflection within control limits. However when you use the hyperboloid in conjunction with a barrel or convex roll, uniform loading is established and $WL^2/8$ is in order.

Walter Siegerist: The roll shape is a true hyperboloid that revolves at an angle to the axis. The curvature changes affect the type of material. As the ultimate tensile strength increases the elastic limit also rises, and there are some materials that our machines are straightening now that have elastic limit and tensile strength so near to each other that the material must be heated, such as aluminum bronze alloy, high speed drill stock, etc. Such materials are heated to about 1200 degrees and then put through the straightening machine, because at room temperatures such materials act like cast iron and break. In others, where the differential is great enough, the high elastic limit requires a greater deflection. More deflection must be obtained, hence this hyperboloid must be generated at a greater angle, and that is done by setting the roll at a higher angle in the roll grinding machine.

For ordinary work the grinding wheel on the roll grinder traverses the roll at an angle of around 32 or 33 degrees to the axis of the roll. If you go to 125,000 or 130,000 psi tensile material, you may be required to go to a traverse angle of 35 to 38 degrees to get a roll with sufficient depth of curvature and the resulting greater deflecting capacity. The deeply shaped roll will also straighten the low elastic limit steels since the operating angle of the roll in the machine is variable and an increased roll angle in the machine will give a reduced bar deflection. However, an increased roll angle shortens the path of contact which in turn reduces the number of straightening cycles per pass through the machine.

On the hyperboloid, when you decrease the angle of the roll you increase the amount of bend toward the center, and the higher the elastic limit the smaller is the roll angle used to do the work.

The straightening of a uniformly tapered round section can be done and is being done in a two-roll machine by a special device that produces a uniform pressure on the straightening roll. We have worked on the problem of straightening round rifle barrels. We worked that out so we could straighten them at the rate of 150 an hour. Heretofore this has been a hand operation.

One post-war problem is the straightening of tubular golf shafts. The golf shaft manufacturers have written to us, stating they do not propose to do it by hand any more. But that is something we are not worrying about at this time.

H. M. Brightman: How about a tapered spar?

Walter Siegerist: That can be done if there is not an abrupt shoulder at the change of diameter, because you must have a uniform bending action. You must constantly exert the bending moment as you pass over those points where the diameter changes. There is a limit, but if the tapered portion is long enough to give you the angle, you can do the straightening in a two-roll rotary machine with a constant roll pressure device.

(*Please turn to page 63*)

Ferrous Electric Welding -

FACT AND FABLE

. . . . the art of welding has many possible applications yet unexploited . . . . some fallacies built up around the welding industry are actually stumbling blocks to progress . . . .

by D. Bruce Johnston

ASSISTANT TO RESEARCH DIRECTOR

LUKENS STEEL COMPANY

COATESVILLE, PENNSYLVANIA

▲ IN international politics we hear a great deal about the welding of nations to form a united front against a common enemy. The word is used in a general sense and implies nothing more than the uniting or bonding together. In the engineering field we think of welding in much the same terms, that is, the uniting or bonding of one or more component parts to form a single coordinated unit. It is at this stage, however, that the line of thought of each individual digresses from the general into the specific field, and each one thinks of welding in terms of a particular field of application or type of welding dictated, in general, by reason of association, either through direct or indirect contact with his own or other industrial organizations.

While it may be somewhat academic, it might nevertheless be appropriate to remind ourselves that welding in a general sense may be defined as the joining of metals by the application of heat. This may be further modified by the statement that welding implies the joining of metals by the application of both heat and pressure in various combinations. Most of us are familiar to a greater or lesser extent with welding done by heat alone and also with welding done by the application of both heat and pressure. We might add that it is possible to make welds using pressure alone without the application of heat, though for obvious reasons such methods would be impractical for most commercial applications.

With the advent of World War II, the use of welding, as in World War I, has advanced by leaps and bounds and it is probably true to state that a very large number of people at present employed in the use of welding in one form or other have been drawn into such work by force of circumstances without having had either any previous experience or training along these lines. It is very obvious, therefore, that many such people have not had the opportunity of obtaining the necessary training in the basic fundamentals which are an essential part of any industrial process.

The art of welding in general has attained a sufficiently high status throughout industry, and enough experience has been gained in the myriad fields of its application, that papers of all kinds and varieties have been written on most phases of the work. Some of these have been extremely simple in character and some, particularly the later ones, lean towards the technical side. When called upon to write a paper on the subject of welding, it becomes a somewhat difficult matter to introduce anything fundamentally new in character. However, in view of the conditions under which we are working today, wherein the use of welding has made such tremendous strides, the author has considered it pardonable to step back a little and discuss the basic fundamentals, in order that those who have only recently entered the welding field, and who perhaps have had no opportunity to obtain such information, may acquire a brief insight into the different types of welding and their application. At the same time it is hoped

Presented before A. I. S. E. Philadelphia District Section Meeting, December 4, 1943.

to point out some of the fallacies that have been built up around the welding industry, brought about partly by ignorance or superstition. Many of these constitute definite psychological stumbling blocks in the operation of the industry.

HISTORICAL DEVELOPMENT

Welding in its crudest form is nothing new in the life of man, and in fact goes far back into antiquity. The first method of welding known to man was the blacksmith forge weld which is still very much in evidence today in many forms. Archaeologists have discovered examples of the early welding of bronze ornaments and utensils in the tombs of the ancient Egyptians.

As means were discovered for the smelting of iron ore for the production of iron, the use of forge welding of this material naturally followed. There are records to show that the use of iron was known about 1000 B. C. and similar records show some knowledge of the development of steel as far back as 300 B. C. Methods for joining pieces of these metals were naturally developed. Much of this early work seems to have been pioneered in India where great efforts seem to have been made to develop the art. Many examples of the early application of forge welding still exist in India, the most famous of which is probably the column which stands in front of the Great Gate at Delhi. This column is 23 feet high and consists of many small pieces of iron welded together in an extremely intricate and painstaking pattern. The column is estimated to weigh six tons, and is reputed to have been made in the year 415 A. D. It still stands as a monument to the patience and ingenuity of craftsmen who were without the modern tools to which most of us are accustomed.

There is no real evidence to show a marked improvement in mediums for joining metals over the centuries until we come to the 19th century, introducing the industrial era which today has reached such staggering proportions. It was during the latter part of the 19th century that the use of electric arc welding was first discovered.

ELECTRIC ARC WELDING

The first record of the use of electric arc welding appears to cover the work done by the Russian engineers, Bernardoz and Demeritins, in 1880, utilizing a very large number of storage batteries as a source of electrical supply. They seem to have persisted with the use of carbon arc welding both in Russia and subsequently in England. In the year 1886 Elihu Thompson patented an a-c welding machine, though this was not for arc welding.

It appears that a man by the name of Thomas Heaton first proposed the use of a mild steel arc welding electrode for use in England in 1893, but at the time the idea was discounted as being impractical. Yet in 1897 a patent was issued to a Mr. Coffin for the use of a mild steel electrode.

Electric welding seems to have been used in the United States for the first time in the year 1902 and was given a great impetus during the first World War.

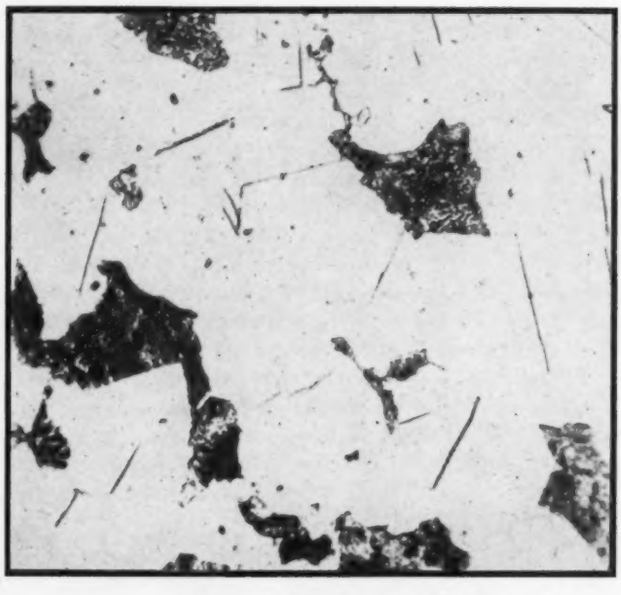
Before jumping too far ahead let us examine the transition from the blacksmith weld into electric arc welding. The blacksmith weld is accomplished by bringing the metal up to a plastic state and applying considerable pressure, whereas the electric arc involves complete fusion of only a small portion of the base metal. Therefore, an arc weld is nothing more than a minute casting with all the characteristics of a cast structure. This particular feature should always be kept in mind for it will sometimes account for some of the apparent peculiarities occasionally exhibited by welds. Although the pioneer work had been done with the use of a carbon arc with or without the use of a filler rod, the use of a metallic electrode soon found its proper place. This however, did not change the fundamental nature of an arc weld, namely, that of being a miniature casting.

BARE WIRE

The inception of arc welding as we know it today was based on the use of bare wire utilizing d-c as a source of current. It might be well to mention the fact that the term "bare wire" implies ordinary wire such as fence wire, etc., which has at least an oxide coating. It would be exceedingly difficult to weld with a chemically bare wire since there would be little with which to form the ionizing vapor which is necessary for maintaining the arc. The use of bare wire developed slowly from the turn of the century up to the beginning of the first World War at which time its use was very much expanded. It may appear to be somewhat antiquated to describe the use of bare wire other than in an historical sense, but it is well worthwhile mentioning here, even though somewhat briefly, since there is still a substantial quantity of bare wire used throughout industry.

It is common knowledge to any one connected with the making of steel that it has a high affinity for oxygen at elevated temperatures, and when using bare wire no exception is found to this fundamental fact. The molten

Figure 1 — Nitrides in bare wire weld appear as long needles. White areas represent ferrite and black areas pearlite (100 X).



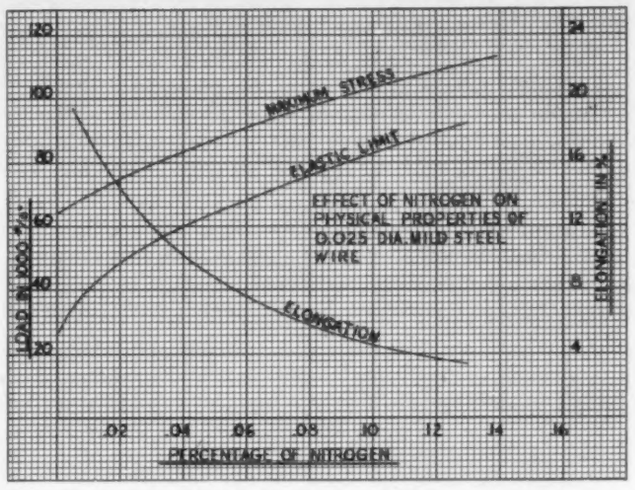

EFFECT OF NITROGEN ON PHYSICAL PROPERTIES OF 0.025 DIA. MILD STEEL WIRE
ELASTIC LIMIT
ELONGATION
PERCENTAGE OF NITROGEN
ELONGATION IN 2"

Figure 2 — Effect of nitrogen on physical properties of .025 in. mild steel wire.

It has been a common failing of the welding enthusiast to go so far overboard in his enthusiasm for the process that he wants to weld everything and anything, regardless of its weldability from the metallurgical standpoint or its feasibility from the manufacturing standpoint. He immediately wants to put the forge shops, the foundries and riveting shops out of business, and yet it is an established fact that all of these processes are today thriving and enjoying a very healthy existence. This is one of the fallacies of welding.

COVERED WIRE

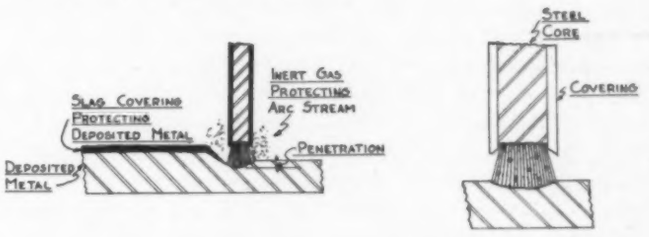
It was early recognized that, in order to obtain a deposited metal of higher ductility, it would be essential to protect this metal during its passage across the arc stream and its subsequent deposition as a weld. This then led to the development of a coating for the wire, and a man by the name of A. Stroemengher was one of the pioneers in this work in the years prior to the first World War. Initially, therefore, the coating was designed to fulfill one function, namely that of protecting the molten metal from contamination by the atmosphere. This was accomplished in two ways: (1) the coating contained a substantial amount of volatile material which created an inert gas shield around the arc; (2) the residual slag formed from the coating gave additional protection to the arc stream but was more effective in protecting the metal after deposition. This action is illustrated schematically in Figure 3. In this it was eminently satisfactory but with the rapid advancement of the use of welding both during and after World War I, the coating, in addition to its primary function of protecting the molten stream, was also used as a carrier for the various chemical elements which it was desired to introduce into the final deposit in order to improve its physical properties.

It is not the purpose of this paper to go into the different types of coatings commercially available on rods currently on the market. Their number is legion and it is another fallacy in the welding industry to state that any one rod in a general classification is any better or any worse than a competitive rod in the same classification. In connection with this, it is worthy of note that the A. W. S. has currently issued a tentative specification for iron and steel electrodes which is designed to bring all the various wires on the market

metal, in its passage from the electrode to the work in the arc stream, has nothing to protect it from the oxidizing effect of the atmosphere. The oxygen, of course, combines with the carbon in the steel to form CO and CO_2, which are driven off as gases. In addition to this, the molten metal absorbs nitrogen which appears in the metal in the form of needle-like crystals known as nitride needles (see Figure 1). Note the thin long strips of the nitride needles referred to above. As a result of the contamination of the metal by oxygen and nitrogen we obtain a deposit which is extremely low in carbon content and at the same time extremely brittle. In the ordinary way, iron with a very low carbon content, such as the "ingot irons," is extremely soft, and as a result has low strength and high ductility. At first sight therefore it seems somewhat paradoxical that a bare wire weld in which carbon is practically nonexistent should have a relatively high strength. Some time ago the author came across a curve showing the effect of nitrogen content on the strength of steel wire, drawn from data obtained by Professor N. Tschischewski.

Figure 2 demonstrates clearly that, in spite of the fact that there is almost a complete absence of carbon, there is still considerable strength. According to the specifications for allowable unit strength of weld metal established by the A. W. S. the strength of a bare weld is approximately 80 per cent of that obtained by the use of a covered wire. However, the ductility of a bare wire weld is in the region of four to six per cent corresponding to a nitrogen content of 0.11 to 0.12 per cent, and this in itself was probably a major contributing factor to the development of the covered wire. Ordinary mild steel plate has a ductility ranging 20-30 per cent in 2 in. While in no way advocating or recommending the use of bare wire, it should nevertheless be borne in mind that bare wire does have its application. It can be used in a structure which is statically loaded with the absence of impact, and where a large part of the welding is either vertical or overhead. At least let it be said that the use of bare wire should not be discounted arbitrarily as a blanket policy, though its mention here is primarily for the purpose of illustration.

Figure 3 — (Left) Schematic cross section of hand welding with covered rod. (Right) Enlarged cross section of covered rod during welding.



today within certain general classifications. This specification, when issued in its final form, should be of great help to the welding industry and to the individual user who is at present in a very confused state of mind as to the best type of rod to use for his particular application.

ROD COATINGS

It is well, however, to have some general conception of the different types of coating used. These can be divided into three very general classifications:

(1) *The dipped electrode* — These are manufactured by dipping bare wire in a liquid solution and subsequently passing the electrodes through a drying oven. The dipping may be done a number of times, depending on the thickness of coating required.

(2) *Medium coated electrodes* — These may be of the dipped variety wherein the rods are dipped a number of times to give a relatively thick coating or they may be of the type wherein the coating is applied by means of extrusion.

(3) *Heavily coated electrodes* — These may also be of the extrusion type but also include rods on which the coating is wrapped. This wrapped coating frequently consists of asbestos wound around the rod in spiral form which acts as a sort of binder for an extruded coating, or asbestos woven into a fabric which is also wound around the rod and achieves the same purpose. The coatings can further be subdivided into two separate classifications, the mineral or inorganic coating and the vegetable or organic coating. As intimated, elaborate claims have been made by commercially interested parties to the effect that this rod or that has certain additional features which others do not possess. Such claims belong to the category of fable and folklore, and can be bracketed with similar commercial claims regarding cigarettes, insurance and the like.

One of the confusing features of present day welding is the large number of covered electrodes on the market, each one having a different color. This is a source of much mysticism and black magic, and is merely a hindrance to the welding industry. The different colors have a psychologically bad effect on the welding operator. If he is trained to use a certain make of rod, he will raise all kinds of objections to using another make of rod even though it exhibits all the characteristics of a competitive rod except color. In an extreme the author has known of cases where welders have complained of becoming sick when changing to another make of rod. In one company, when the change was made some years ago from bare wire to covered wire, there were a number of cases of welders complaining of sickness, some actually having to go home. The insurance companies have proved this to be one of the gross fallacies which has attached itself to welding. Please note that the above remarks refer to the use of ordinary arc welding on the more common type of steel. There are cases, such as welding over a galvanized plate, where the fumes are not only obnoxious but dangerous.

D-C VERSUS A-C

At this stage it would be well to dwell briefly on the relative merits of the use of d-c and a-c as a primary source of current. In all arc welding it is essential to have a high enough voltage to ionize the arc stream and maintain this ionization. With the use of bare wire, it will be very obvious that it is only possible to use d-c for welding. When an attempt is made to use a-c there is not a sufficient reservoir of either heat or ionized vapor to enable the arc to get started after the sine wave of current passes through zero. With the use of covered rods, however, it then becomes possible, in some cases, to utilize a-c in place of d-c, though here again limitations are placed on the use of a-c partially due to the fact that there is an insufficient reservoir of heat referred to, and partially because the coating is of such a nature that the voltage required for ionization is high enough to preclude the maintenance of a stable arc. It is not the intention of this paper to discuss the theory or the chemistry of coatings, since this represents a profound study and knowledge of fluxes.

There is one distinct disadvantage with the use of d-c. A peculiar phenomenon becomes very pronounced and at times exceedingly objectionable. It is noticeable when using d-c that the deposition of metal is made somewhat difficult by the presence of what is known as "arc blow." This is due to the effect of the magnetic field on the arc stream which produces a visible effect of motor action. When welding in the middle of a plate or structure, this effect may or may not be pronounced, or sufficiently bad to be objectionable. However, if found to interfere with the quality of welding, a common solution is to change the position of the ground lead. It is very obvious, when one stops to consider it, that with d-c the magnetic field is directional and the moving of the ground lead can change the direction of this field in such a manner that it does not react so violently upon the arc stream. However, when approaching the edge of a plate, the magnetic field then tends to draw the arc toward the center of the plate, making it a very difficult matter to deposit the metal where required. This effect is extremely pronounced in a corner at the junction of three welds.

The use of a-c eliminates this condition of arc blow or, perhaps it should be said, it eliminates it insofar as any visible effect is concerned. Alternating current, of course, is nothing more than a direct current following a sinusoidal pattern and changing direction 120 times per second. During each half-cycle therefore, the basic causes for arc blow are still present. However, since this change occurs 120 times a second, there is undoubtedly enough physical and electrical inertia in the arc stream to eliminate, for all practical purposes, the results of the effect of arc blow.

At this stage, we should take cognizance of polarity. This, of course, is quite fundamental with anyone who has in any way touched on electricity. When using d-c, it is very important to know which is the positive and which is the negative pole. It is one of the popular misconceptions, not only of the welding industry, but also of the electrical industry in general, that electric current passes from the positive to the negative pole. It has been definitely established, however, that current actually passes in the opposite direction, that is, from the negative to the positive pole, and it is universally agreed that the positive pole is hotter than the negative pole. No two authorities agree on the exact degree of relative heat, but a ratio of 1:2 between the negative and posi-

tive poles can be accepted as approximate values for this heat distribution. In welding terminology, the use of these two poles is referred to as "straight polarity" or "reversed polarity," respectively. Straight polarity is defined as the condition prevailing when the electrode is negative and the work is positive, and reversed polarity is, of course, the opposite.

It becomes very obvious that, in bare wire welding, the relative sizes of the welding rod and the plate or weldment are such that it is essential to have the heat distributed in a proportionate manner. If reverse polarity is used, either the rod becomes over-heated or insufficient penetration is obtained in the plate.

When using covered rod, the question as to whether to use straight or reversed polarity then arises. Going to the extreme, with the use of heavily coated rods, reversed polarity is invariably used. In this case, additional heat is required by the rod in order to melt the coating and at the same time, the plate, which is the negative, has to receive enough heat input in order to obtain complete fusion. Again it is very obvious that the only means possible of accomplishing this is to supply more electrical energy; in other words, to raise the amperage. This then is the reason why higher currents can be used with the heavily coated electrodes. The use of higher currents melts more metal in a given time, with consequent increase in production. The question of which polarity to use on rods falling into some category between the bare and heavily coated classifications is a matter to be determined either experimentally or according to the recommendation of the manufacturer. Some rods on the market can be used with either straight or reversed polarity to give equally good results.

It has been stated earlier in this paper that the use of a-c, when utilizing bare wire, is quite impossible. With the use of lightly coated electrodes, it is extremely difficult and not recommended. In the heavily coated series, however, enough heat is created in the arc crater at the end of the rod so that the arc itself can get re-started after the voltage passes through the zero point of the sine wave. There are many rods, which, because of the thickness of the coating and the chemistry of the coating, can be used equally well with d-c or a-c, and the selection of the welding rod should be governed not only by the type of equipment available, whether a-c or d-c, but also by the product to be welded.

There is one other distinctive advantage which a-c has over d-c and that is in the matter of equipment. In d-c, two systems are generally used. The more efficient, from the purely electrical standpoint, is to use individual motor generator sets. The second system, frequently used where many welders are constantly employed, is to have a large, constant-potential motor generator set, usually supplying between 70 and 100 volts open circuit, with a number of resistor banks for the individual welders. The latter system is inefficient electrically, but represents a smaller capital investment if the number of welding outlets is sufficiently large. Both, however, are objectionable from the standpoint that they necessitate the use of rotating machinery, with the attendant evils of initial high cost and subsequent maintenance.

The use of a-c involves equipment which is much simpler and, in addition to representing a lower initial investment, also involves lower maintenance costs in that there are few moving parts to wear out. Here again two systems are used. The first, which is practically universal in this country, involves the use of a single welding transformer for each operator, the primary usually being connected to a 440 volt line. Such a welding machine incorporates a choke with the welding transformer for controlling the output current. The other system, which the author has only seen used in Europe, involves the use of a large transformer supplying constant potential, the welders using an individual reactor to control the welding current.

The design of welding machines is not a subject to be covered by this paper, and it is sufficient to note that in a well designed welding machine the characteristics are such as to bring the voltage down from the open circuit value to normal welding voltage with the maintenance of a stable arc. In the older type of machines the open circuit voltage was sometimes as high as 120 volts but the modern tendency has been to bring this down, and present day machines are usually built to give 80 volts open circuit. An open circuit voltage of 120 volts was originally used in order to facilitate the starting of the arc. However, this has one serious objection. During the summer months, the perspiration from the operator reduces the insulating ability of the welding gloves, and there is serious danger of sustaining an electrical shock. While in the ordinary way this voltage is not high enough to cause injury, it is sufficient to cause a welder to recoil instinctively. If he happens to be working at the top of some structure, there is then danger of his falling off and sustaining serious injury. With the present day welding rods, an open circuit voltage of 80 volts is sufficient.

The question is raised as to whether the deposited metal is better with d-c or with a-c, and there seems to be no evidence to show that one is any better than the other. The choice is usually dictated by the type of rod employed. In actual operation, it is no more difficult to use one than the other. It might be mentioned, however, that the use of bare wire calls for much more skill in the down hand position than with covered wire. In any position, welding with bare wire is not an easy matter. Due to the fact that there is a very rapid heat loss from the arc stream, it is necessary to hold a very close arc and maintain this closeness within narrow limits. When using covered wire, however, the coating assists materially in maintaining the arc, more particularly in the downhand position. In general it might be said that welding with bare wire requires a much higher degree of skill than that required when using a covered rod.

With the use of covered wire, the myth that arc welding requires a peculiar type of skill disappears. The advent of a war has created the necessity for training a very large number of welding operators in a matter of weeks and, where this work is down-hand, anybody with average intelligence and a small amount of skill can master the technique in a few weeks. However, it requires a considerable degree of skill to make vertical and overhead welds, and such skill is not easily acquired. Arc welding is probably the most versatile of all the welding processes and there is very little in the ferrous field which cannot be welded. However, the economics of the process must be kept in mind and the

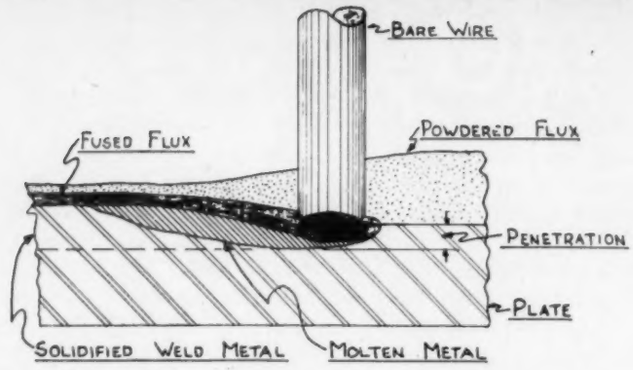
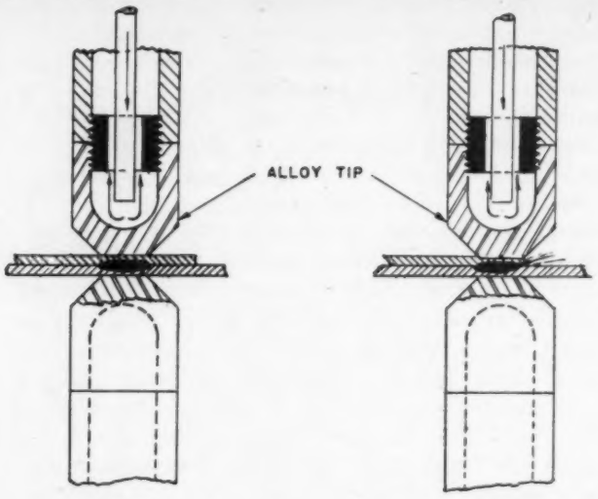


Figure 4 — Schematic cross section of Unionmelt welding.

▲

Figure 6 — Vertical section of two electrode tips spot-welding lapped sheet metal, showing, at right, expulsion of metal because of insufficient lap. →

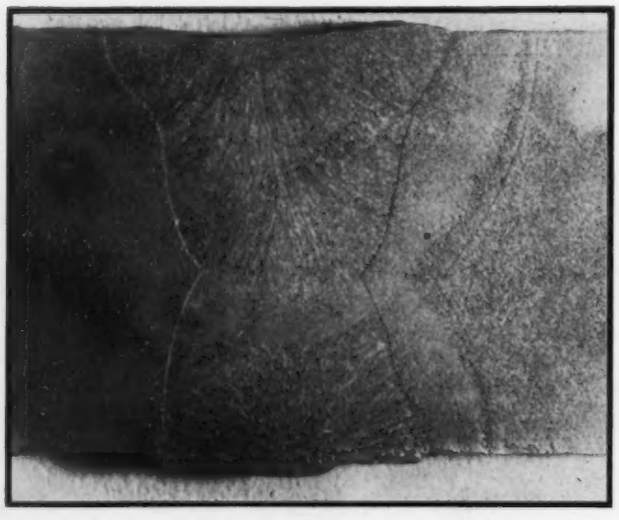


incorporation of forgings and castings where suitable can reduce the cost of a weldment considerably.

AUTOMATIC ARC WELDING

With reference to automatic welding, as a general statement it might be said that this represents nothing more than the elimination of one or more hand operators and their replacement by one or more machine operators. It might also be stated that automatic welding has two objectives: (1) the maintaining of consistent quality, and (2) cost savings obtained by speeding up production. There is a great danger of jumping to the conclusion that manual skill is to be eliminated and that the requirements will be only for an automaton. This represents one of the gross fallacies of the welding industry and is an error of which many otherwise efficient executives and supervisors have been guilty.

Figure 5 — Section of Unionmelt weld in 2 in. plate showing the overlapping of the welds made from each side of the plate.



Some types of welding, by their very nature, lend themselves exceptionally well to automatic operation. Spot welding is a very good example, and automatic control of this type of welding has been carried to a very fine point. In selecting automatic equipment, the user must be very careful to decide first on the necessity for, and second, the suitability of, such equipment to his particular problem. Automatic equipment usually represents a considerable investment, and the decision to change over to automatic welding should therefore entail considerable thought and planning.

In the case of automatic arc welding there are three general types: bare wire, covered wire, and bare wire used with a powdered flux. All three types operate on the same general principle, that is, the arc length, as represented by the voltage drop across the arc is maintained at a constant predetermined level, usually by means of electronic control. Essentially, an automatic arc welder consists of three elements: (1) means for feeding the welding wire, usually from a reel; (2) means of moving the wire forward in the direction of welding; and (3) control equipment for operating the above.

Welding with bare wire with the use of a powdered flux is something which has come into the picture within the last few years and, like any other machine or process, has a very definite place in industry. In general, in using this type of automatic arc welding, the current densities are very much higher than those ordinarily used in hand welding being, possibly, three to four times as great. Figure 4 shows a schematic longitudinal section of a typical weld of this type. In this particular process the heat of the welding arc fuses some of the powdered flux to form a very heavy slag over the surface of the metal, which not only protects the metal from oxidation but also keeps the arc in a very quiescent state. After the weld has been completed, the unfused flux can be recovered for reuse and the fused portion can usually be removed very easily. A typical set of welding conditions is to use a ¼ in. wire at 1000 amp and 32 volts with a welding speed of 8 in. per minute. Such conditions would be

capable of penetrating to a depth of almost ¾ in. from the surface of a flat plate. By the utilization of proper welding conditions and the preparation of the adjacent edges, it is possible to weld plate up to at least 2 in. thickness with one pass on each side. This is based on the author's own experience, though numerous articles have been written in which claims have been made to the welding of 4 or 5 in. material with one pass on each side. This type of welding introduces certain problems and practices which are not necessary in manual arc welding. In the first place, the fact that such high

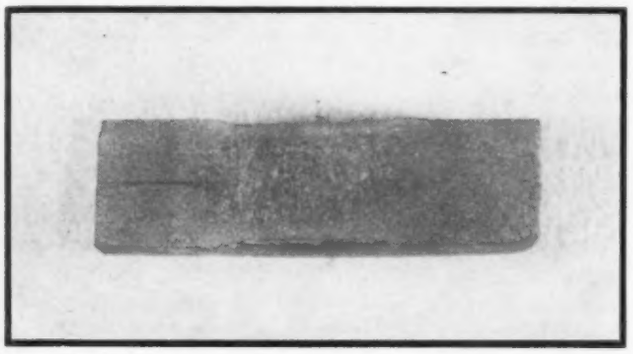


Figure 7 — Section of spot weld in 2¼ in. plates.

currents are being used means that there is a long crater, as shown in the illustration. When welding ceases, there is great danger of this crater cracking and it is therefore essential that a run-off pad be employed so that all of this crater may be off the joint being welded. When the weld starts, a short time elapses before full penetration is established, and for this reason it is also essential that a starting pad be employed. These starting and stopping pads may be of bar stock or small pieces of plate of approximately the same thickness as the plate being welded.

It is the considered opinion of the author that many automatic welding machines, and particularly those employed in jobbing shops, are not just push-button affairs, but require a much higher degree of knowledge and judgment than that required by a hand operator, and as such, should be placed on a higher economic plane than the equivalent hand operation. In this way good results are more likely to be obtained.

At this stage, the author would like to discuss, very briefly, some of the other forms of ferrous welding which are commonly used and, while it is not intended to go into any details, they are mentioned here in order to give an idea as to the possibilities of welding.

Figure 6 shows the general principle of spot welding. Essentially this process involves the application of high pressure with a very strong current for a short period of time. The process is limited entirely to lap welds, and is usually not used commercially for plates over ½ in. thick. From the illustration, it will be noted that the current has to pass from the electrodes through the two plates to the other electrode. Due to the contact resistance at the surfaces of plates, this current generates a sufficiently large amount of heat at the adjacent surfaces of the plates that the latter are fused together.

Figure 7 shows a section of a spot weld made in ordinary steel. This process is an old one and the development has been mainly along the lines of control equipment. The process lends itself extremely well to sheet metal and is being used very successfully in the welding of stainless steel and other alloys. The main problem has been in the matter of control of the time of application of the current. This is usually of very small duration, sometimes being as low as one or two cycles. In this connection, there are two considerations. The first is the melting of the metal adjacent to the electrodes. The second consideration is a metallurgical one which is extremely important when welding alloy steels. For example, in the spot welding of stainless steel, the heat input has to be controlled so that there is no metallurgical change in the steel which will affect its stainless properties. It is obvious that the contacting surfaces of the pieces being welded must of necessity become molten, but the timing of the welding operation must be such that the temperature of the exposed surfaces of the metal in contact with the electrodes must not be raised above the critical temperature. If this happens, carbides will be precipitated and the stainless properties of the steel impaired.

There are numerous modifications of spot welding, and it might be of interest to mention the type known as stitch welding. In this case (Figure 8) the electrodes are composed of two copper wheels in place of the cone shaped electrodes usually used.

The metal sheets or plates are placed between these rollers and current is applied periodically. A series of

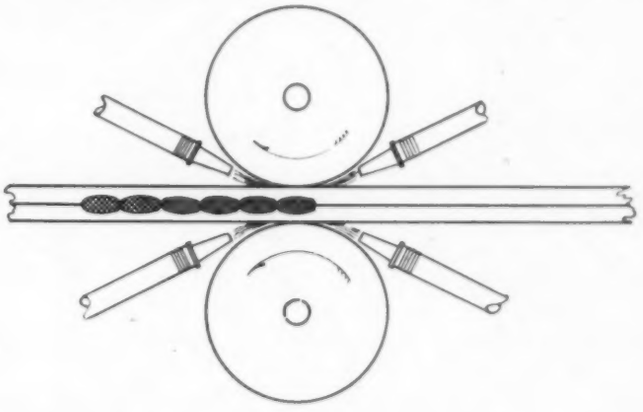


Figure 8 — Side elevation of wheel electrodes of seam-welding machine, having four water jets.

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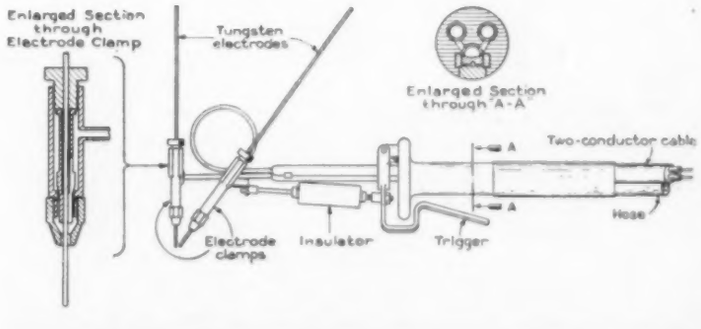
Figure 9 — Side elevation of electrode holder for atomic hydrogen welding.



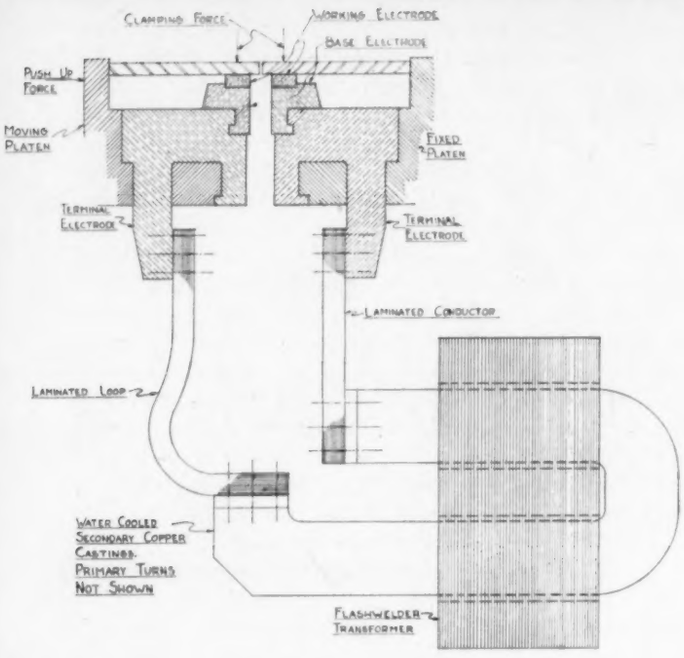


Figure 10 — Schematic drawing of typical secondary power circuit for flashwelding.

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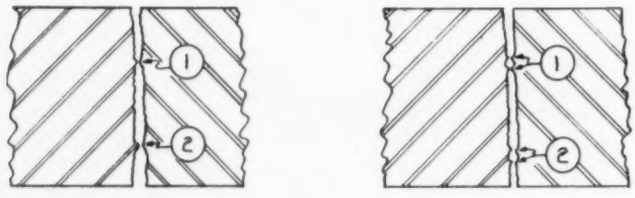
Figure 11 — Schematic cross-sections of flashwelding during burn-off period.



spots are made and the time interval is such that these spots overlap to produce the effect of a continuous weld. This application is usually confined to thin gauge sheets and is used very extensively in the fabrication of items such as refrigerators. A variation of this type of welding is to maintain the current continuously, in this way making a continuous seam.

ATOMIC HYDROGEN

Another form of specialized welding is by the atomic hydrogen process, the welding head for which is illustrated in Figure 9. Essentially, this consists of two tungsten electrodes, which can be brought together and pulled apart at the will of the operator. They are usually brought together to establish an a-c arc which is then drawn between the ends of the electrodes as they are moved apart. At the same time, the electrode holders throw a stream of hydrogen towards the arc. This hydrogen serves two purposes. Initially, it is consumed by the heat of the arc, and in so doing the molecules are dissociated. As these dissociated molecules strike the cold plate, they are reassociated and in so doing release a large amount of heat which is used as the welding source. The secondary function of the hydrogen is to protect the weld from oxidation by the atmosphere. This process is limited to relatively thin gauge material but produces a weld of extreme purity and high ductility.

FLASH WELDING

With ordinary arc welding, the process is so flexible that the purchase of a welding machine and some welding rods, constituting a relatively small investment, enables any back alley shop to get started in the welding business. The application of flash welding, however, constitutes a major investment which only relatively large shops are capable of sustaining.

Flash welding comes under the general heading of resistance welding in the American Welding Society's classification of the various welding processes, and is limited entirely to butt welds. Furthermore, the pieces must be of substantially the same cross section. Briefly speaking, this type of welding is carried out by the use of considerable pre-heat followed by high push-up pressure.

Essentially, a flash welding machine consists of a press which, in the smaller sizes, may be operated mechanically by a cam or, in the larger sizes, hydraulically. Operation may be fully automatic, semi-automatic or hand controlled. One platen is fixed and one movable (see Figure 10). At the end of each of these platens nearest the weld line there is bolted a large copper casting and both can be referred to as the terminal electrodes, which in turn are bolted to heavy flexible leads connected to the secondary loop of the flash welding transformer. On top of the terminal electrodes a working electrode is bolted, this working electrode being different for various types of jobs. In some cases an intermediate base electrode is placed between the terminal and working electrodes in order to reduce wear and tear on the terminal electrodes which form an integral part of the machine. Means are provided for bringing the moving platen into fixed stops, the final position of the moving platen relative to the fixed platen being controlled by some mechanical adjustment.

The pieces to be welded are clamped tightly against the working electrodes, usually in some type of jig or fixture. They are then brought slowly together until they touch, at which time flashing commences. It should be clearly understood that flash welding is essentially a process which utilizes low voltage and exceedingly high current.

The open circuit voltage for flash welding varies from ¾ to 20 volts, the actual voltage depending on the size of the piece to be welded, that is, the number of square inches of sectional area which have to be welded. Such a wide variation is not usually found in any one machine. The actual voltage during welding probably drops to a very low value, and while it may be possible that an approximation of the actual voltage could be arrived at by calculation, no attempt will be made to do so here due to the number of variables involved. The current density, that is, the amperes per square

inch, is of a very high order. The American Welding Society's handbook gives the limits as 2000 minimum and 25,000 maximum. There is no very accurate method of measuring this current (which probably accounts for the exceedingly wide range given by the handbook) but the author believes the actual figure to be around 5000 or 6000 amperes per square inch. It should be borne in mind that these figures of current density represent the total amount of amperes flowing divided by the square inches being welded, which in the absence of more specific information is a purely arbitrary method of expressing the unit current required. It is quite possible that during the initial stages of welding, at least, the actual current density may be well over 1,000,000 amperes per square inch. As the pieces are brought slowly together, they will eventually touch at a single point which causes an extreme rush of current through this point, in turn causing it to melt and vaporize in a minute fraction of a second. As the pieces are moved closer together, other points touch in turn and likewise vaporize. This is illustrated schematically in Figure 11.

Contrary to the belief of many people, there is no maintained arc as such during flash welding, but rather a series of short circuits as described previously, which, during the initial stages of flash welding, cause a very violent explosive action, and which, coupled with the high magnetic forces present, throw out the metal as minute molten particles. As a result of these short circuits the ends of the pieces heat up, and as they are moved forward, more points short-circuit until after a certain length of time a more or less stable condition is arrived at where a very thin film of semi-molten metal is formed all over the welding faces with a very sharp temperature gradient back from these faces to the cold parent metal. The exact distance back varies with the plate thickness, but for a one-inch plate this might be ½ in. to ¾ in. back. When this condition is reached, each short-circuit or explosion causes a crater to be formed in the surfaces of the adjacent pieces, and since these are in a semi-molten state, the force of the explosion which causes these craters also has the effect of pushing the metal out from the edge of the craters to form a very ragged perimeter. This then causes a new source of points for short-circuiting and eventually this state of affairs continues in such rapid succession that the molten metal being thrown out appears as an almost uniform series of sparks, hence the term "flash-welding." A large 1000 kva flashwelder is shown in operation in Figure 12.

Figure 12 — Flashwelder of 1000 kva capacity in operation.

During all this time metal is being melted off and thrown out. This is known as the "burn-off" period, which continues until a pre-determined amount of metal has been burnt off each piece. This is followed by a "push-up"; that is, the pieces are forced together under high pressure which may be done hydraulically but is frequently done by means of a heavy cam. The use of a cam is limited by the total load that can be applied by such means, and when this has been reached it then becomes necessary to use one or more hydraulic cylinders. The amount of this "push-up" varies with the size and shape of the piece but in the case of 1 in. plate it is ⅜ in. to ½ in. total. This causes the steel, which in the immediate vicinity of the welding faces is in a highly plastic state, to push out or extrude to form a very ragged hump known as the "upset" or "flash."

Figure 13 — View of a good flashweld made in a 4½ in. diameter bar. The flash is open, indicating a good weld.

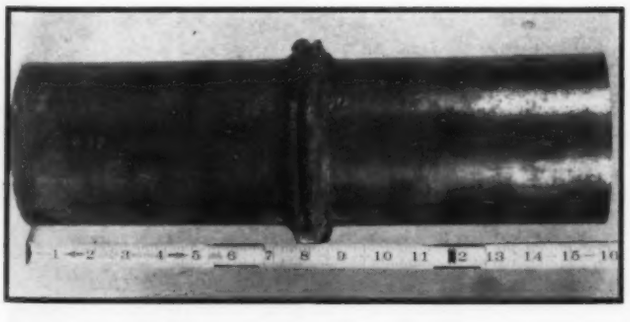
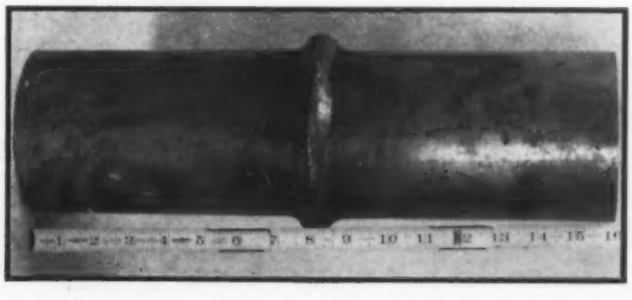


Figure 14 — View of a poor flashweld made in a 4½ in. diameter bar. The flash does not have the same open appearance as shown in Figure 13. This indicates insufficient upset.



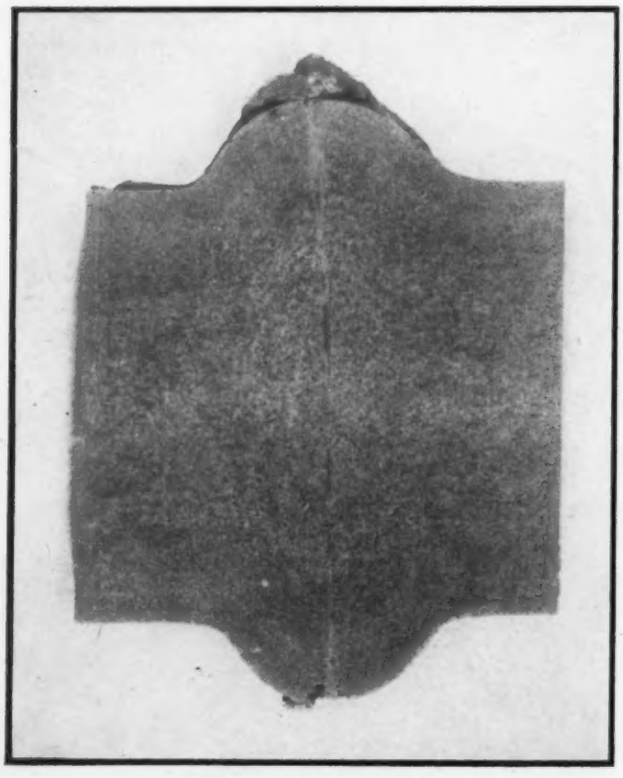
This action squeezes out the molten metal, together with any particles which may have been oxidized due to their proximity to the surface.

As soon as this "push-up" period begins a sufficiently large percentage of the welding surfaces short-circuits to cause the current density to fall to a point where it is insufficient to maintain the flashing, which then ceases. Momentarily there is then the danger of the hot metal being oxidized within those sections of the joint which have not yet touched, and in order to prevent or reduce this danger, it is important that this "push-up" be done as rapidly as possible. Figures 13 and 14 show a good and a poor flash weld respectively made of a 5½ in. round, and Figure 15 shows a section of a poor flash weld made in plate material 3¾ in. thick.

There are objections to both the cam and hydraulically operated types of machines. In the case of a cam there is a limit to the rapidity of the push-up. In the hydraulically operated machine the variation in the viscosity of the oil due to temperature changes may cause erratic operation. The best combination, for smoothness of operation, is to utilize a cam for the burn-off period and a hydraulic cylinder for the push-up.

The actual time of cutting off the current after the starting of the "push-up" period is controlled by two main factors: metallurgical considerations and sizing of the piece. Regarding the first factor, it is very obvious that certain types of steel which are sensitive to heat treatment can be affected by the time during which the current is held after push-up. In such cases this time must be controlled very closely. Regarding the second factor, if the overall welding conditions are not exactly

Figure 15 — Section of flashweld in 3¾ in. plate made with insufficient upset. Dark lines near the center of the weld indicate nonfusion which is the result of insufficient upset.



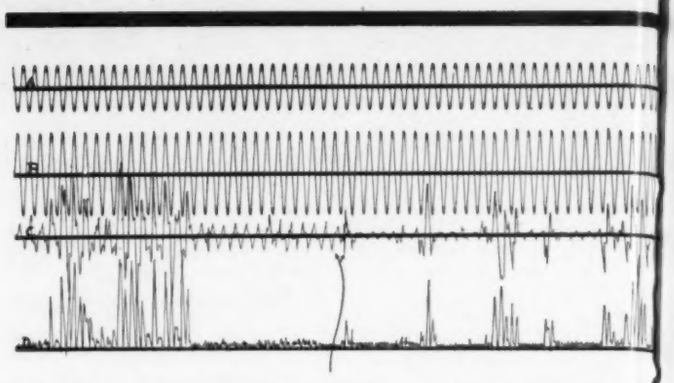


Figure 16 — Oscillogram of flashweld. Curve A is the timing wave at 60 cycles. Curve B is the primary voltage wave. Curve C is primary current. Curve D is primary power. Arrows point to the primary current curve at the time of tap changing from which it will be seen that both the primary current and power drop.

right (thinking in terms of hand operation), it is just possible that if the current were cut off too soon after the start of the "push-up" period, there would not be sufficient plastic metal to enable the machine to push the pieces to correct size; but if the current is held, the additional heat thus created increases the plasticity of the metal and enables the machine to come into its fixed stops.

After the weld has cooled, the "up-set" or "flash" has to be removed by chipping or grinding before the weld can be regarded as being complete.

The actual unit pressure required in order to produce a satisfactory upset varies considerably with the type of steel being welded. The A. W. S. fixes the range of unit pressure between 5000 and 25,000 psi. In ordinary mild steel a pressure of 10,000 to 12,000 psi is usually sufficient, whereas for an SAE-4140 steel this value approaches 30,000 psi.

It is very clear, however, that if the electrical conditions and the amount of burn-off and push-up are correct, the actual unit pressure, as determined theoretically from the pump pressure and the area of the cylinder, is immaterial, provided it is high enough. Metal in any one stage of plasticity can only resist so much pressure, and since the machine is set to come up against fixed stops, no excess pressure can be transmitted to the weld itself.

The welding of large sections introduces some problems which are not found when welding small ones. In order to enable the welding to be started and maintained, it is necessary to use a high voltage — of the order of 16 volts — which will enable a large amount of current to flow in the circuit. After the burn-off period has progressed to a point shortly before the up-set, sufficient heat has been built up in the pieces so that this high voltage is no longer necessary but, if maintained, will cause a very violent and explosive action. It is quite conceivable that if, immediately prior to upset, a particularly violent explosion occurs at some section, it will create a crater sufficiently deep that when the final upset is made, the bottom of these craters will not come together with sufficient force to cause complete fusion. It then becomes desirable to incorporate some device which will change this voltage

to a lower value at a predetermined point during the welding cycle. This can be accomplished by an automatic tap changer such as is used in power distribution systems for changing taps under load, or electronically, by means of phase control.

When dealing with two pieces of the same material, it should be noted that, since there is no addition of any external filler metal, there is only a metallurgical change in the metal and none in its chemical composition. Thus the hardness across a section of a flash weld does not vary over a very wide range, and if it were suitably heat treated to restore the original metallurgical conditions, only a very small variation would be noticeable. This is in direct contravention to an ordinary hand weld wherein filler metal is added in the form of an electrode which deposits a chemically different metal of low carbon content, usually about 0.06 C. In such a weld the hardness cannot, by any form of subsequent heat treatment, be made to give as uniform a hardness as a flash weld which is made without the addition of any external filler metal.

Figure 17 is a view of a typical flashwelder installation. The clamping mechanism consists of a 6¼ in. hydraulic cylinder on each side of each platen. These operate vertically through hinged levers along the sides of the platen to actuate two "hold-down" beams, each one of which holds the pieces being welded tightly against the working electrodes. The levers on one side of the machine hinge vertically about fixed fulcrum points but the other two on the operator's side of the machine (foreground in picture), in addition to hinging vertically, are mounted on pivots so that they may be rotated horizontally for the purpose described later.

In general, there are two types of hold-down or clamping beams used, the removable type which, after each weld, are removed or hinged out of the way in order that access may be had to the pieces being welded, and the "rigid beams" which are permanently bolted to one set of levers and thus move up and down with them. In both cases the levers on the operator's side can be rotated to load or unload the machine. The removable beams are used for welding anything flat, such as plates, forgings, or castings. The rigid beams are used only for welding rings, and since these beams are attached to the one set of levers, the rings can be threaded over the beams. When using the removable beams, these have to be completely lifted off to load or unload. With the rigid beams, however, the rings are threaded over the beams, the rotating levers brought into place and the whole clamped ready for welding.

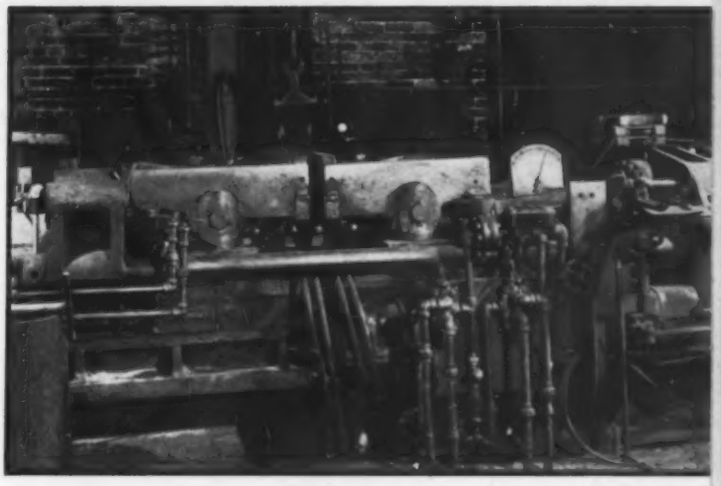


Figure 17 — Typical flashwelder installation.

Up to the present time, the maximum area that it has been possible to weld successfully on this machine has been 30 square inches. In this particular case, two pieces were being welded to form a single ring. Figure 18 shows that the cross section being welded was not at all uniform, and further demonstrates the versatility of flashwelding. This picture also demonstrates that more than one section can be flashwelded at one time. The pieces after flashwelding are shown in Figure 19. Since the process is essentially one of short-circuiting and burning off, it is quite possible to weld a number of sections simultaneously, for the first one touching is the first one to burn off and, as more points approach, they

Figure 18 — Half ring having a cross section of 28 sq in.

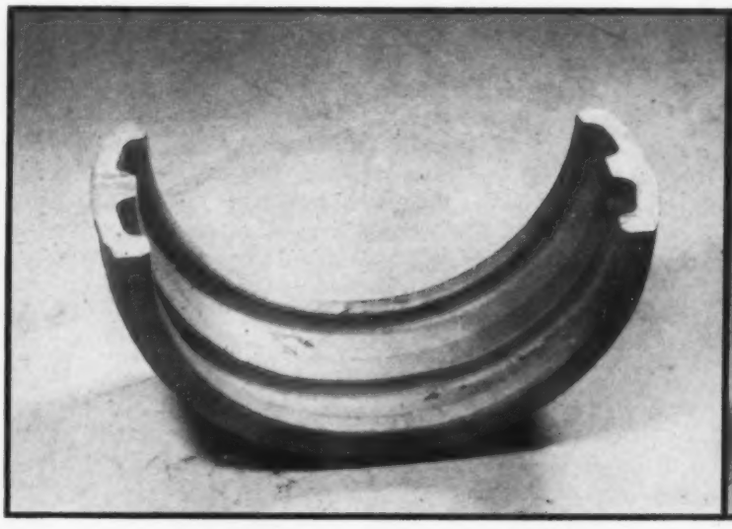
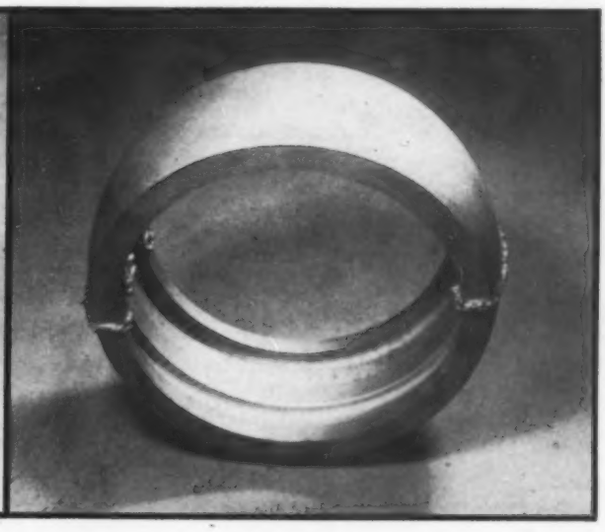


Figure 19 — Flashweld of two pieces as shown in Figure 18.



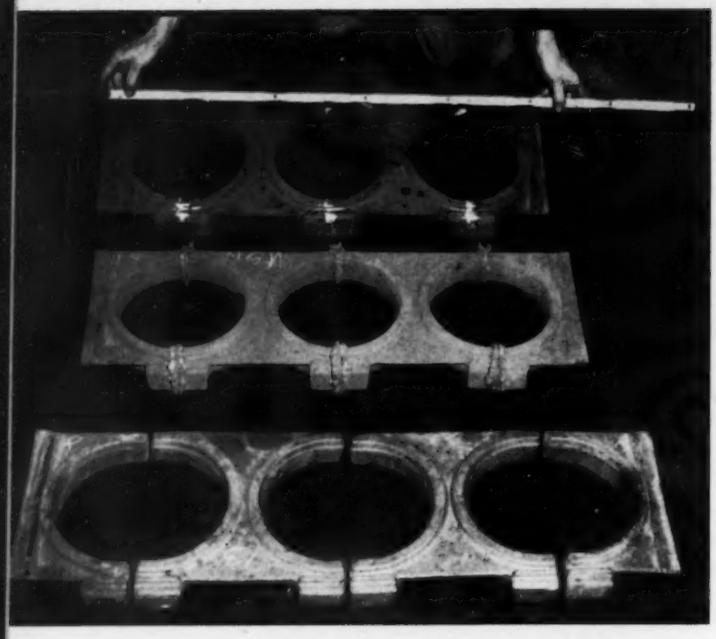


Figure 20 — Flashweld assembly made from four small forgings. Top view shows finished assembly after chipping and grinding of the flash.

in turn burn off. While Figure 18 shows that it is possible to weld pieces which are not uniform in section it must be borne in mind that too great a variation in section might lead to trouble. In all cases, opposing sections must be of substantially the same contour.

Flashwelding probably has its best application in the welding together of numerous small forgings or castings to form a single large assembly. In this way, simple and inexpensive component parts may be used, which in these times are more easily obtained than larger pieces. It is well known that at the present time there is very little large forging capacity available but there are innumerable small hammers which have been converted to war use by the automobile industry. Small forgings are therefore much more readily available than large ones, and a double savings is therefore afforded by flashwelding — time and cost.

For purposes of designing fixtures, it is usual to allow for a shrinkage of $\frac{1}{64}$ in. per flashwelded joint. Thus, for welding an assembly which has eight welds in it, the total allowance for shinkage would be eight times $\frac{1}{64}$ in. or $\frac{1}{8}$ in. Theoretically this is not strictly correct, for as pieces are added to the assembly the welds previously made are cooling off. However, enough heat seems to be retained to make $\frac{1}{64}$ in. per joint sufficiently correct for practical application.

Flashwelding has many applications and the author would like to take this opportunity of mentioning one instance which had certain unusual features. In this particular case an SAE-4140 steel was being welded to an austenitic steel of the chrome-nickel series. During the burn-off period the austenitic steel burned off at a more rapid rate than the 4140, due to its lower melting points. At elevated temperatures, however, the austenitic steel had considerably more strength than the 4140. Specifically, at 1800 F the austenitic steel was $2\frac{1}{2}$ times stronger than 4140 at the same temperature. During push-up, therefore, the austenitic steel did not upset as much as the 4140, which tended to off-set the excess of metal lost by the austenitic steel during burn-off.

In order to give some idea of the current values used in flashwelding, the author would like to mention some figures taken from actual measurements. The machine with which he has had a considerable amount of experience has a rating of 1000 kva and a total push-up pressure of over half a million pounds. From tests, it has been established that the particular installation will give a maximum current of approximately 2800 amperes at 480 volts, which, with a turn ratio of 31 to one on the flashwelding transformer, would give a secondary current of 2800×31, or almost 90,000 amps. With this capacity it has been possible to weld 30 square inches commercially, and the author is of the opinion that it should be possible to weld a maximum of about 35 square inches, although the opportunity to try this has not yet arisen. Plans are going ahead, however, for the flashwelding of even heavier sections.

The art of welding has many applications, some of which still remain unexploited. Out of the present war some good must emanate and doubtless welding in its various forms will emerge in a considerably more advanced state than it otherwise would have been.

DISCUSSION

PRESENTED BY

W. M. SHOBER, Electrical Superintendent, Aluminum Company of America, Beverly, New Jersey

D. BRUCE JOHNSTON, Assistant to Research Director, Lukens Steel Company, Coatesville, Pennsylvania

J. W. DEIMLER, Electrical Design Engineer, Alan Wood Steel Company, Conshohocken, Pennsylvania

W. M. Shober: With reference to the lines, you have two contact points. Do you have any trouble with current distribution?

D. Bruce Johnston: You are undoubtedly referring to the illustration showing the flash welding of small forgings wherein two sections or projections from one forging are flash welded to two similar projections on a mating forging. No trouble whatsoever has been experienced in making a flash weld of this type. It has been explained that flash welding is little more than a series of short circuits, each one removing a certain amount of metal. If one of the two sections referred to above tends to burn off more quickly than the other, then after a short period of time, the latter will make contact, causing flashing at that section. While it is not discernible to the eye, undoubtedly flashing alternates between one section and the other in irregular flashing, thus automatically adjusting itself to a uniform current distribution. In the particular example

(*Please turn to page 63*)

Developing A PRACTICAL *Safety Program* IN THE STEEL PLANT

. . . . the country needs man power . . . . we should not rest until we have done everything we can to prevent waste of man power through accidents . . . .

by G. H. Fosdick

SUPERINTENDENT OF BLAST FURNACES

BETHLEHEM STEEL COMPANY

BETHLEHEM, PENNSYLVANIA

▲ WE all know that accidents interfere with production, and that we cannot afford to lose any production at a time when Uncle Sam wants more steel to make weapons for victory for our boys over there. Accidents are a disgrace in peace time, but when we are engaged in a terrible war, they are a national menace as well.

It is gratifying to know that the Association of Iron and Steel Engineers and the steel industry have played a leading part in the work of accident prevention, and have pioneered in promoting and fostering the safety movement. Today, as a result of this, we find the steel industry one of the safest of all industries, with a frequency excelled only by the tobacco and the cement industries. In fact, the steel worker is actually safer at work than on the street or in his own home.

Thirty years ago we at Bethlehem realized that if the number of accidents were to be reduced, the mere placing of mechanical safeguards would not suffice. Our employees would have to be educated and made to realize and appreciate the value of safety. Up to that time there had been very little if anything done in the way of accident prevention, and the handling of accident cases was crude, to say the least.

The first move in the safety campaign was the appointment of a safety engineer. Fortunately for us, the selection was a good one. Starting from scratch, with nothing to work with except an abundance of enthusiasm, he proceeded to build up an organization for the dissemination of information about safety and accident prevention. A chief safety inspector assisted by one or two inspectors was appointed. Their duty was to investigate unsafe working conditions, to report on causes of accidents, and to make suggestions for their elimination. In 1914, almost a year later, the management agreed to hire a full-time graduate doctor. A modern dispensary was built and an ambulance purchased. Brightly painted guards put in their appearance around gears and dangerous moving parts, and "Safety First" and "Caution" signs were prominently displayed.

The "infant" was on his way, but not without many trials and tribulations. Here was something new, and it was laughed at and sneered at by men and superintendents as well. Even within the safety department itself, everybody wasn't thoroughly sold on the idea. The first chief safety inspector selected wanted to take some girl friends to a dance one evening, so he used the plant ambulance as a means of conveyance. (Please note that the past tense is used in speaking of him.) Men still took chances, and the guy who reported to the dispensary for the treatment of a minor injury was a sissy. Even as late as November, 1917, when, due to the

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tremendous increase in the working force caused by World War I the safety engineer was promoted to superintendent of labor and safety, several of the leading superintendents, shaking hands with his successor, said they did not know whether to offer congratulations or condolences.

I happen to know, because I was the new safety engineer. I had just been moved over from the mechanical department where I had been serving as steam engineer.

Fortunately our general superintendent recognized the value of safety and agreed to serve as the first president of the Lehigh Valley Safety Council. I will not give you the exact date, but suffice it to say that we are proud of the fact that the council carries the number "five" in the whole United States. This council, like all other local councils, is made up of representatives of all industries in the valley. Functioning through the National Safety Council, they foster safety education not only in industry, but in the schools, on the street and in the home.

Another factor which began clamoring for attention and which could not be overlooked was the matter of workmen's compensation. As early as 1913, the Pennsylvania State Legislature was discussing the formulation of a compensation law. The labor bodies were pushing it and many meetings were held between labor, management and state representatives before it finally became law in our state in 1915. Its enactment did two things: first, it defined a compensable accident and established a definite schedule of payments to the injured, and second, in its very first paragraph it stated clearly, concerning the liability of compensation that "the burden of proof is on the employer." This, in my opinion, helped to put the first real teeth in the safety movement.

Whereas, in the early stages, great stress was laid on machine guarding, it soon became apparent that the greater number of injuries and fatal accidents could be prevented by education. The State Department of Labor and Industry, as well as our own safety organization kept a record of all accidents, together with their causes and remedies. The early statistics began to show that as many as 80 per cent of all accidents could be prevented by education alone. Someone discovered that even a match has a safety head.

A course in first aid training also began to shape up. As early as 1915 our electrical department won a meet in competition with other departments in our corporation. These meets have grown to the point where they now include not only departments from the steel plants, quarries, shipyards and mines, but also teams made up of boy scouts and girl scouts, and workers from certain allied industries. During the stress of war time, they have again been more or less limited to competition within the plant. Many thousands of our employees, through this training, have not only learned the value of first aid and the importance of treating injuries, but have acquired valuable safety training as well. How often have we heard cases of electric shock, gas poisoning and drowning that have been saved through the knowledge of some first aid trainee? Does everyone realize that it is the first five minutes that often mean the difference between life and death?

Last summer I spent a Sunday with one of the superintendents at his cottage on Trout Lake. As we were ready to leave, there was some commotion down the lake and some one yelled that a little boy was missing. I got there perhaps 15 or 20 minutes after he had disappeared and finally two men in a row boat fished him out of the lake. His mother was walking out in the water up to her neck determined to find the boy or to go under herself. I was the only one in the crowd that seemed to know much about artificial respiration. Unfortunately, too much time had been consumed in locating the boy, and although we worked on him until the ambulance arrived from a distance of 10 miles, we were too late. How different it would have been if only five minutes instead of 20 or 25 had elapsed before we found him.

In the early days safety committeemen were appointed in each department, a practice which has been continued. These men have definite duties to perform in their own department, and are usually selected from men who can get around and devote a certain portion of their time to safety. They are called permanent safety committeemen, and have always done a good job. Today there are 89 of these committeemen in the plant, devoting a goodly portion of their time to safety. They meet once a month with members of the safety engineer's staff and talk over their problems.

From the very beginning, safety codes were developed for each department by the superintendent of the department working in conjunction with the safety department. Fifty-nine different codes have been developed and a printed code is given to each new employee before he starts to work.

Safety posters and bulletins are furnished to the various departments each week, to be posted on the 174 safety bulletin boards distributed throughout the plant.

Nine large jumbo poster sign boards are located at various entrances to the plant, on which are placed safety posters as well as war bond posters.

The foregoing development has taken place over a period of about 20 years. The "infant" has grown into a good size child. According to records compiled by our central safety organization, in conjunction with the seven other steel companies, with whom we exchange information, our accident records were probably as good as most of the others, although not outstanding.

Then came the lean years of 1931 to 1935. Like everyone else we curtailed wherever possible, in order to exist. Safety was more or less allowed to rest on its laurels, and very nearly became an orphan.

When a Pennsylvania Dutchman is getting the worst of an argument, a favorite expression of his is "let it lay so." Well, we began to find that you can not let safety "lay so." If you do not move forward, you have a tendency to slip back. You can not preach and think safety one minute, and forget it the next. There are no short cuts or easy ways out.

Two horrible examples stand out in my mind in this connection. We had a general foreman in one of our large machine shops, a good man, who talked safety to his men. One particular thing that he always stressed to them was never to walk under a big gun forging when suspended by an overhead crane, but walk around it.

One day this foreman, for some unknown reason,

forgot his own teachings and ducked underneath one of these big forgings instead of walking around it. It took only a fraction of a second, but that was enough. It was the Great Divide for him.

The second example concerns myself. I do not want to deal with personalities, but when World War I was over, I was transferred from the safety department to the blast furnaces. I do not know whether I had a let-down or whether I was over-zealous or just a plain fool, but in the short space of about six months I had been burned, knocked cold by blast furnace gas, and hit in the head by a 10 pound sledge, needing four or five stitches to close up the cut. It was then that I began to ask myself what was wrong with me. Here I had come from a job talking and preaching safety and the only reason my check did not come down off the wall was because the good Lord wasn't ready to take it down. These examples are used merely to illustrate a point.

Starting in 1936, we began to pick up where we had left off. It took us several years to regain our breath, but during the past five years we have begun to show some real progress. As our work increased, 50 full time safety supervisors, in addition to the safety committeemen mentioned above, have been placed in the various departments, reporting directly to the department superintendents. This is in addition to the safety engineer and the five safety inspectors of the central safety organization.

These safety supervisors handle all safety matters in their respective departments, such as the placing of new employes, first aid training, dispensing of safety clothing, shoes, goggles, bulletins, impromptu safety meetings, the placing and maintenance of guards, cleanliness, salt dispensers for heat cases and many other items. They meet once a week as a group with the safety engineer's group.

Each department holds a monthly departmental safety meeting, conducted by the superintendent and attended by the foremen, safety supervisors, permanent safety committeemen and a representative from the safety department. Many departments hold a short daily or weekly meeting attended by all employees in a particular group.

The general manager holds a monthly safety meeting, conducted by the assistant general manager. Every superintendent, assistant superintendent and all safety supervisors attend, as well as representatives from the plant and the corporation safety departments. Any absentee must have a legitimate reason. A safety paper is read by a superintendent and one by a safety supervisor. All "lost time" accidents are covered by each department superintendent. The responsibility for any accident is placed squarely on the shoulders of the department superintendent concerned, and he must get up and explain the circumstances surrounding the accident as well as what steps he has taken to prevent a recurrence. Charts are displayed showing the relative standing of each division, as well as the standing of our plant compared with that of the other plants, and our corporation standing in the seven company exchange. Statistics and an impromptu talk are given by a representative from the central safety organization and the meeting is brought to a close by a "pep talk" from the general manager.

A — Each one of these safety shoes saved a foot. Safety shoes are a "must" in most steel plants today.

▲

B — Gas masks are provided wherever the work brings the man in contact with gas. A gas school is maintained for training employees.

Discipline is probably a distasteful word to some people, yet every successful general and every successful campaign must have it. Eisenhower and Montgomery have it. We have sometimes found circumstances in connection with our accidents or safety program which have made it necessary to demote some of our foremen. Any superintendent who is not "sold" on safety, first, last, and all the time, has no place in our organization. Any operator who does not hold in front of him at all times the idea of treating his fellow worker the way he would like to be treated himself had better step aside and make room for a better man. This must include safety.

For a number of years our program has included such items as periodic crane inspections, a central department for testing and repairing chains, etc. In the past five years we have added such items as designating all

new employees by means of a 2½ in. diameter button bearing the name of the company and universal safety insignia. Buttons for minors, boys between sixteen and eighteen years of age, and buttons for newly hired hernia cases are also issued. We have tried to make these buttons attractive and they serve as a caution sign for our supervisory force to use these men where they can best be fitted in. Under the stress of war and the draft we have been obliged to hire anybody, male or female, that can wear a pair of pants. This is not different from any other establishment, however.

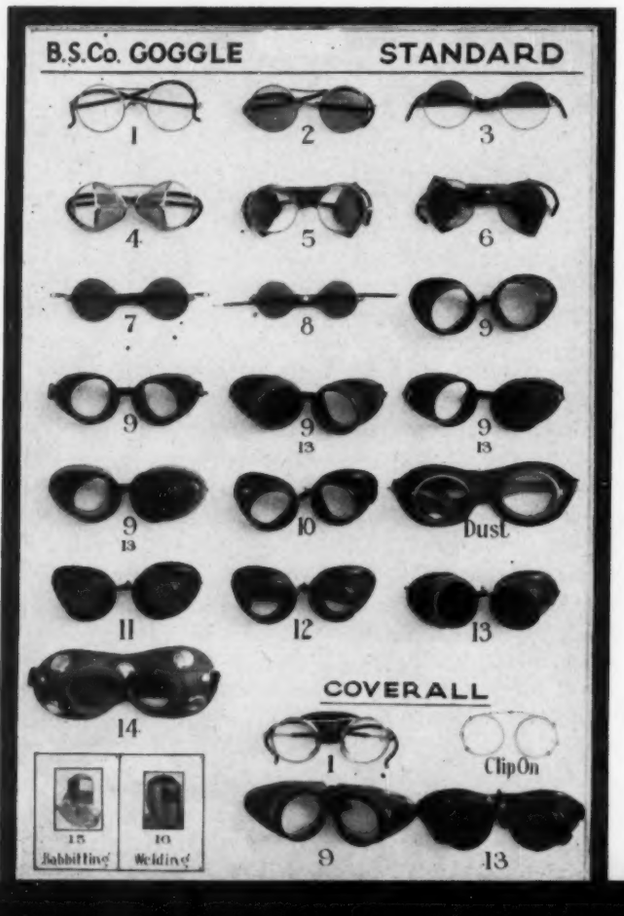
We have been asked to present a paper on the development of a safety program. Before you can develop a program, you must really understand what safety is.

What is safety? Is it a slogan? No. Is it a mechanical safeguard? Of course not. Safety is alertness, safety is education, safety is cleanliness and cleanliness is next to godliness. Did you ever hear of a good safety record in a dirty plant? Safety is production. Did a corpse ever produce guns and ships and planes? Can a cripple take his full share on the production line? Safety is the ability to treat others the way you would like to be treated yourself.

Did you ever actually see a man killed? Have you ever seen one "pass on" after an accident? Did you ever have to tell a woman with several kids hanging on her dress, that her husband would not be home tonight? If you have, and you were not jarred loose from your bootstraps, roll over, brother! You're a mummy and have been dead for the past 2000 years.

If you retain all of these things, then you are ready to map out a program. What "makes" for a successful program? Here is what our assistant general manager says:

C — A wide range of goggle types meets the requirements of all work in the plant.



"We have handled safety as our first responsibility as managers of the plant — from Mr. R. A. Lewis, our general manager down to the sweeper on the open hearth floor, from the division superintendent to each superintendent, to foremen, to straw boss — handling the safety function as any other basic activity — raw materials, delays, costs, production, records, engineering, etc. We carry out the policies and instructions of our whole corporation through the conscience and interest of our organization. Where certain members of our organization are too busy or over worked — as are some of our superintendents and foremen — then we assign a man as safety supervisor.

"It is an educational process, and cannot be intensified by short cuts, or quick panaceas. It must be planned as any other education program."

Let's emphasize that sentence "We carry out the policies and instructions of our whole corporation through the *conscience* and *interest* of our organization."

There are people in these United States who think that there is no conscience in the steel business. For their information, I would like to state that, including our president, Mr. Grace, from the leading officials on down, there are God-fearing men with a conscience in the steel business.

To my mind, the last few paragraphs explain the reason for a successful safety program. Has ours been successful? Well, I don't know — judge for yourself:

During World War I, from 1916 to 1918, we had an average of 38 fatalities and 2783 accidents per year, with a frequency of 36.61.

In 1942 with a greater working force we had 15 fatalities, 106 lost time accidents and a frequency of 1.70.

For the first six months of 1943 our force has increased 14 per cent, our lost time accidents have decreased 13 per cent and our fatals 71 per cent, compared with the first six months of 1942.

When I was safety engineer in 1917, we had some hazardous occupations that carried a compensation insurance rate of $1.50 per $100.00 of pay roll. Our compensation provision in 1942 was 13½ per cent, and for nine months of 1943, 7½ per cent, of the 1917 figure.

In 1941, we won the National Safety Council trophy with a frequency rating of 1.99. This was in competition with 25 leading steel plants.

In 1942 our frequency dropped from 1.99 in 1941 to 1.77. However, some of our competitors had done a little better job, so we finished in the runner-up position.

In the first 8 months of 1943, our frequency rate dropped to 1.35, putting us in first place again."

Does safety stop at the plant gates? We think not. I have previously mentioned the fact that our general superintendent helped to organize the Lehigh Valley Local Safety Council, serving as its first president. Since that time, many of our men have served in an official capacity. In 1941 and 1942 J. M. Sylvester, our present assistant general manager, served as president. During his regime, he instituted monthly meetings held one afternoon each month and attended by the city officials, the state police, members of the school board, school teachers, officers of the Chamber of Commerce and civic bodies as well as members from industry. We

D — Suitable protective clothing is worn by everyone working around hot metal.

feel that these meetings were very helpful. Our safety department sends out accident information comparing the number of fatal and lost time accidents occurring to our employees both on and off the job.

I am sorry to state that the figures show that over three times as many fatal and lost time accidents happen to our employees when they are away from work as occur at work. Most of these occur on the highway or in the home. During the first seven months of 1943, two of our employees were killed in the plant against eight outside. We have had 51 lost time accidents to our employees inside the plant and 173 on the outside. This bears out the statement that our men are safer in the plant than away from it.

What are we going to do about it? It means that the same kind of a comprehensive plan of safety must be carried out outside the plant as on the inside, through the local safety council, the schools, the police and various civic organizations. More people are killed and injured in highway and home accidents every year than were killed in the American forces in World War I. The new driving speed of 35 miles per hour has cut highway accidents down materially, but until we have education and discipline, and until someone in high places takes the nuts behind the steering wheel and hangs a few of them, we will not make any real progress.

We are proud of our safety record in the plant, but we are much prouder of the fact that, due to the united efforts of all our employees, there are many little tots in our community who are able to run out and greet "Dad" at night.

We are not content to rest on our laurels and it behooves every operating man in the steel industry to bring his accident rate down to that irreducible minimum, both in the plant and out. If our safety plan possesses any particular merit or ideas that can be of service, our management will be only too happy to help in this great cause. The country needs man power, and your conscience and mine should not rest until we have done everything we can to make this a better and safer United States.

DISCUSSION

PRESENTED BY

A. J. FISHER, Fuel Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

A. H. FOSDICK, Superintendent, Blast Furnaces, Bethlehem Steel Company, Bethlehem, Pennsylvania

C. C. HENNESSEY, Superintendent of Safety and Police, Pittsburgh Steel Company, Monessen, Pennsylvania

H. B. DUFFUS, Safety Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

JOSEPH CARTER, Carnegie-Illinois Steel Corporation, Homestead, Pennsylvania

E. A. ELLIS, Director Welfare and Safety, Wheeling Steel Corporation, Wheeling, West Virginia

A. J. Fisher: I would like to have Mr. Fosdick explain the qualifications of the fifty safety supervisors in the Bethlehem plant. In other words, if he were employing a new one, what qualifications would he set up?

A. H. Fosdick: As I said, even a match has a safety head. First and foremost, a safety supervisor must have

a certain degree of intelligence. He must be imbued thoroughly, first, last and all the time, with the safety idea and the point that I tried to bring out, that if you are not willing to treat the other fellow the way you would like to be treated yourself, you have no place in the organization. I think that applies very, very much to the safety supervisor. In other words, he is the big brother of the department.

So if you can picture a man with a certain amount of intelligence who is willing to look out for the welfare of all the rest of the employees, you have a man who probably has the qualifications of a good safety supervisor.

C. C. Hennessey: I was wondering what Mr. Fosdick meant when he described a badge for hernia. Is that post-operative that they wear that?

A. H. Fosdick: I think that is a good question. Of course, we are all very much up against it for help. We have found it advisable to go out and hire men who already have a known hernia case. Of course, everybody entering the employ of the Bethlehem Steel Company, and, I presume, of all other large steel companies, must undergo a physical examination. Heretofore, we have been a little careful in not taking on men with a hernia case, because as the compensation law started off in the very first paragraph, the burden of proof is upon the employer, and I assume that all employers are a little bit cautious in that respect. But today we are hiring men that actually have a hernia before they come into our employ. and it is surprising that there are quite a number of these men.

For that reason, we not only put it down in our records, but we also put the badge on the man, so that no one of our supervisory forces or anybody else connected with our organization will give that man a heavy job where he must do a certain amount of lifting or put him under stress. That is the reason we put that badge on him. It is a pre-hiring case, a man who already had a hernia before he came into our employ.

Member: You mentioned that safety supervisors of the central safety organization have, among other things, the responsibility for the placement of new employees. I was interested in this. Does that mean that the safety supervisors are in direct charge of the induction of the new employee, or does it merely mean that they have to approve the employment of the applicant? I am interested in your induction program.

A. H. Fosdick: I don't know whether I made it clear that these fifty full-time safety supervisors are not a part of the central safety organization. Of course, they are under their supervision, but they report directly to the superintendent and are a part of his force. It is their duty to take all new employees, provide them with the safety code, give them a thorough instruction in safety, and actually take them and place them on the job, turning them over to the foreman after they have been instructed thoroughly in all matters pertaining to safety. Of course they do not go into production matters or instruction. That matter is left in the hands of the superintendent and the foreman, but each one of these fifty safety supervisors reports directly to the department superintendent in the department in which he is working.

Member: We all, of course, are interested in the employment of minors, boys sixteen to eighteen years old. I noticed in your paper that you said you had a special badge which these boys wear. Is this badge merely a means of identification to show that the boys are under the age limit of twenty-one?

A. H. Fosdick: We have three badges, as I brought out in the paper. We have a circular badge, two and a half inches in diameter, that denotes the new employee. We have a small badge which is about a half inch high and possibly three inches long, with the word "Minor" printed on it. We also have another badge for hernia cases.

The reason for putting those badges on the various employees — the new employee, for instance — is that everybody is supposed to give him a helping hand and explain the dangers of his particular job to him.

As far as the minor is concerned, you all realize the stringency of the state laws, and there are certain occupations that a boy cannot be given. There are certain hazards that we don't expose him to. It is the job of every supervisory man, when he sees that sign on the boy, or the hernia case, to assign him only to such jobs as are approved by the state rules or such jobs as they know that man can handle.

Member: What, in your judgment, is the greatest service that a safety man can render you, as superintendent of the blast furnaces and not as an ex-safety man?

A. H. Fosdick: At present everyone is pretty much taken up with production, and for that reason, as our assistant general manager brought out, certain individuals may be overworked. I don't know whether anybody is overworked or not, but we don't devote enough time to safety. Department heads must devote more of their efforts to production. The safety supervisor is really the boss over all safety and welfare activities. He takes all of those matters in his own hands, and of course, if you have a good safety supervisor, he is going to bear down on every item that affects the safety and welfare of all of the employees within the department.

I could not pick out one individual thing that those men perform as an outstanding service. As I tried to point out, there are so many things that make up the whole that if you leave out one of them I think you have missed out on the program.

H. B. Duffus: Can you give us an estimate of the approximate number of people each safety supervisor covers?

A. H. Fosdick: We have on our payroll, at the Bethlehem plant, between 31,000 and 32,000. We have fifty full-time safety supervisors as well as the eighty-nine permanent safety committeemen. The latter are not full-time safety men, but devote a good portion of their time to safety. In addition to that, we have a chief safety inspector in the central safety organization, and five safety inspectors connected with the safety organization.

Joseph Carter: There are a great many new employees going into all the companies today. I would like to ask Mr. Fosdick if he will tell us what his percentage of accidents is among the new employees as compared to the old employees, and if he has any special course of training for the new employees.

A. H. Fosdick: I know that in analyzing our accident cases at the Bethlehem plant there are some months

when we get up and stress the fact that a good proportion of our accidents have happened to new employees, and the very next month we find we have a good many that have happened to fellows who have been there over three years or who have had up to as many as twenty-five or thirty years of service.

I think that is a difficult question to answer. In my opinion, I would say about fifty-fifty. As far as any special course is concerned, as I have already mentioned, the new employee not only is handed a safety code which deals in all of the hazards pertaining to his particular occupation, but he is given a course of thorough instruction in safety by the safety supervisor before he is put to work, and from then on, of course, he is instructed by the foremen and the superintendents under whom he may work.

E. A. Ellis: I would like to ask Mr. Fosdick whether he has found it necessary in his plant to employ female labor to a greater extent than normally and, if so, what experience he is having with them from the safety standpoint.

A. H. Fosdick: At Bethlehem we have the general offices of the corporation, and between the general offices and the Bethlehem plant itself we have 5000 women employed. We are hiring more women every day. As far as the women are concerned, we have found we have had very, very few accidents. We have had no serious accidents with our female employees.

Siegerist DISCUSSION

(*Continued from page 44*)

H. G. R. Bennett: What is your thought in regard to the latest straightening machine which has two motors as compared to the other where they have universal drive?

Walter Siegerist: It is a very popular machine. It is the most popular we have and is the only one we received orders for over the phone after the customer had read the advertisement. The machine is exactly the same principle as the two-roll single motor. The two rolls in this machine are identical to those used in the single motor two-roll machine; it is the method of driving that is different. It is difficult to get the low speed of 20 fpm in the two-roll, two-motor machine. It is essentially a high speed job, because you have the motor above the roll and the only way to reduce the speed is through the connections you get on top of your roll yoke. You cannot cut the speed down below a certain minimum. Aside from that, if you want to straighten very crooked material, which, for safety sake, you may want to put through at 20 feet a minute, it is difficult. We like to start at 60 fpm and go up. If floor space is not an important feature, the two machines are identical with reference to results.

H. M. Brightman: Using the new type roll action, say on the tube .062 in. x .250 in., you mentioned in the straightening operation, by pressure you increased the thickness of the wall and expanded the tube sufficiently to withdraw the mandrel rod, is it not possible to control this pressure?

Walter Siegerist: That pressure can be controlled and we have offered controlled pressure machines for that purpose so that there is a definite load on the derodding operation regardless of the operator. For such work you should use two hyperboloids of revolution for the roll shapes because that will take care of the workpiece without flexing it at all. It will impose the same number of cold rolling cycles thereby expanding the tube from the mandrel with minimum roll pressure.

Johnston DISCUSSION

(*Continued from page 56*)

under discussion the two sections being welded simultaneously were of approximately four and two square inches respectively, and the results obtained with thousands of welds show no evidence of any unequal distribution of current.

J. W. Deimler: How about flash welding copper?

D. Bruce Johnston: I have never had any first hand experience with the flash welding of copper and therefore am in no position to make an authoritative statement on the subject. There are certain things however, which might give trouble. The conductivity of copper is about six times that of steel and for this reason I would expect that a very much higher value for current density would have to be used in order to enable the flash welding surfaces to be brought up to a welding temperature.

J. W. Deimler: I have had a welder in the plant tell me that a-c current wasn't as good as d-c current for welding. Are there definite limitations within which you can get the same results with a-c as with d-c?

D. Bruce Johnston: As a partial answer to your question I would point out that we use a-c almost exclusively in our own shops and have made butt welds in plates of 7 or 8 inches thickness. We do, however, maintain a few d-c machines for use with special rods such as stainless steel which are not suitable for use with a-c.

J. W. Deimler: I am not familiar with the type of rod he is using.

D. Bruce Johnston: I have had men tell me that depositing weld metal in the vertical and overhead positions is made easier by the use of d-c. It is possible to advance a theoretical consideration to back up this contention, since, under certain conditions, it is quite conceivable that use could be made of the differential of heat between the rod and the plate to cause quicker freezing of the metal as soon as deposited. In welding in the overhead position, one has to rely on the surface tension of the molten metal to prevent its falling due to force of gravity. Therefore it is exceedingly important to use, not only the correct length of arc, but also the correct current conditions. In so far as the final results obtained are concerned, I know of no differential when using a-c or d-c.

DEVELOPMENTS IN

Steel Mill Bearings

. . . . lead-base babbitts containing arsenic have been substituted for tin-base alloys with satisfactory results . . . . a method of repairing bearings in bronze, steel or cast iron shells is given . . . .

by H. L. Smith

CHIEF METALLURGIST

AMERICAN SMELTING AND REFINING COMPANY

FEDERATED METALS DIVISION

BARBER, NEW JERSEY

▲ THE problem of steel mill bearings is of interest and common to metallurgists and engineers alike, to the master mechanic, maintenance man, millwright, and in fact every one responsible for keeping our mills in operation. The reason for this, of course, is obvious when we consider that an engine or a piece of machinery can only be as good as its bearings, and since engines and machinery are the root of steel mill operations, it is little wonder today, when we must operate at greatly overtaxed capacities, and are at the same time faced with the loss of such critical metals as tin, cadmium, copper, etc., which formerly were the base of our bearing alloys, that the problem of bearings is one of our biggest and most general ones. Thus, we have been brought closer together in an effort to arrive at the best bearing alloys available that will give satisfactory life and trouble-free service in these trying times.

Problems connected with steel mill bearings are roughly divided into two classes; one involves design and construction, the other operation and maintenance. Under number one, probably the most important problem facing the designer and construction engineer is which alloys, other than tin-base, possess physical characteristics equal to the tin-base babbitts and are therefore suitable for steel mill use. To answer this it is best to consider the history of the old tin-base babbitts. A recent writer on the subject states that the prototype of a bearing metal is still the hundred-year-old babbitt metal (89 per cent tin, 7½ per cent antimony and 3½ per cent copper), one of those truly happy hits of craftsmanship, on the basis of which other bearing metals have been developed essentially by analogy. With such a babbitt available for the past hundred years, and the designer little limited with regard to size and weight of construction, bearing dimensions were adjusted through the years to meet operating conditions. Even with the conventional tin-base babbitt and large bearings, still a great number of bearing failures arise due to deflections of the journal and poor alignment.

Therefore, for the most part, all steel mill bearings of today are oversize compared to their load carrying capacity and service requirements. With this fact established, a comparison of their physical properties will reveal which of the lead-base alloys possess properties equal to the tin-base babbitts and therefore offer themselves as suitable substitutes. From a preliminary survey of the data given in the literature it would seem on the face of it that lead-base bearing alloys are quite the equal and in some cases possibly superior to tin-base bearing alloys but as a matter of practical experience this has not proved to be the case. Tin-base bearing alloys have usually proved their superiority, particularly in internal combustion engines where the bearings are subjected to elevated temperatures. Since the data in the literature cover very largely the properties of lead-base bearing alloys at room temperatures the failure of the physical properties to indicate the

relative merit of tin-base and lead-base bearing alloys is due to the measurement of these properties only at room temperatures. Therefore the properties of the various accepted bearing alloys should be measured over a range of temperatures wide enough to include the highest temperature at which bearings could normally be employed. This procedure indeed indicates that the properties of most lead-base bearing alloys fall off more rapidly with increasing temperature than do the properties of tin-base bearing alloys. A further factor which proves to be of greater significance is time at the elevated temperature. When bearing alloys are held, for example, at 150 C for a period of many days it is found that with all the commercial lead-base alloys the properties fall off much more rapidly with time than do the properties of the conventional tin-base alloys.

As none of the conventional lead-base alloys containing various amounts of tin and antimony have properties reasonably close to those of the tin-base bearing alloys over a range of temperature, it is the purpose of this article to describe two new alloys developed by the company with which the writer is connected, and known as "G" and "S" babbitts. These bearing alloys are essentially lead-base, but contain antimony and arsenic, with a tin content of 1 per cent or less.

The effect of additions of arsenic to lead-base bearing alloys has been studied by a number of investigators and the results show improved high-temperature properties and considerable grain refinement. In addition, Schwartz states that the addition of arsenic to lead-base bearing alloys markedly lowers the coefficient of friction. However, the above quarternary system has not previously been completely surveyed to determine the composition ranges that give the best combination of properties.

The composition stability of "G" and "S" babbitts is most satisfactory and, in addition, the low rate of dross formation promotes economical utilization of these alloys.

Two alloys were developed to cover the widest range of application. Alloy "G" retains its higher hardness at elevated temperature, while alloy "S" has somewhat greater elongation, desirable in certain forming operations. Both alloys have been used in steel mill bearings for the past two years; they are enjoying service and field use in all theaters of war and have replaced successfully more tin than any other conventional alloy.

With the designer and the construction engineers satisfied that certain alloys possess the necessary physical requirements, the second part of bearing problems as previously stated involves operation and maintenance. To operate successfully a bearing alloy must possess:

(1) Comformability — Ability to seat the shaft properly.

(2) Oiliness — Ability to hold a film of oil.

(3) Embedability — Ability to absorb grit without scoring the shaft.

(4) Resistance to seizure — Avoid scoring of the shaft if failure occurs.

(5) Resistance to corrosion — By lubricants and water.

(6) Ease of bonding — Ability to stick firmly to the backing metal.

(7) Ease of repair — Ability to cast easily and put an old bearing back into service readily.

The arsenic lead-base babbitts ("G" and "S", 3 and 1 per cent arsenic respectively) have, in addition to their lower first cost, excellent frictional properties. Their oiliness, conformability, embedability and resistance to seizure, as well as their resistance to corrosion are equal to the tin-base babbitts. This is now proven by actual experience. While these properties are important to the operation of steel mill bearings from a maintenance and repair point of view, probably the most important characteristics of a bearing alloy are ease of bonding and recasting for repair. In this regard, all precision insert-type bearings used in certain diesel engines and similar equipment are as a general rule made and supplied by bearing manufacturers who use very precise and elaborate methods of casting. It is of course desirable to use such methods which include cleaning the shell in a hot caustic bath, water rinsing, and acid and flux dipping, as well as "tinning" by immersing the shell in a liquid "tinning" bath, etc., wherever possible. For maintenance and repair of steel mill bearings however, a much easier method of bonding and casting must be employed primarily because necessary casting equipment is not available.

An alternative method is therefore recommended as follows:

1. Clean the bearing surface of the shell. If chemical cleaning is not available, clean with a stiff wire brush (motor driven, if possible).
2. Immediately after cleaning, apply zinc chloride flux to the surface to be babbitted.
3. Heat shell by immersing in tinning bath until the bonding alloy may be wiped off the bearing surface. Do not keep the shell immersed any longer than is necessary so as not to overheat. (See note.)
4. After bonding alloy may be wiped off the shell, place shell on a table and let cool until, when rubbing a stick of the bonding alloy over the shell, the bonding alloy becomes sticky. A heavy coating of the bonding alloy should be applied to the shell before pouring the babbitt.
5. After adjusting the temperature of the shell as stated, set the shell and mandrel in the usual way and pour the babbitt at as low a temperature as possible, that is, just high enough to eliminate any porosity.
6. After pouring the babbitt, cool the shell from the outside in toward the mandrel and from the bottom toward the top as quickly as possible.

Note — When applying the bonding alloy as in step 3 above, if no kettle of liquid bonding alloy is available to permit immersion, the shell may be heated over a flame and the stick bonding alloy applied by rubbing over the shell surface with an intermittent application of flux. After sufficient bonding alloy is so applied, cool as in step 4, etc.

This method (or modifications thereof which space does not permit recounting) has been used with excellent success in the production of many steel mill and similar bearings on bronze, steel or cast iron shells.

HIGH FREQUENCY

Induction Heating

. . . . neither a cure-all nor a miracle maker, induction heating offers advantages that justify its use in many applications . . . .

by G. E. Shaad

STEEL MILL SECTION

GENERAL ELECTRIC COMPANY

SCHENECTADY, NEW YORK

▲ HIGH frequency induction heating is by no means an infant, for over 27 years ago Doctor Northrup began a series of experimental investigations that led to the coreless induction furnace. Less than six years after the experimental work was started, high frequency equipments totaling more than 1000 kw were in operation on induction heating of many types. It is interesting to note a portion of a paper written by Doctor Northrup and published in 1922:

"As high frequency power becomes more available at lower cost, and in greater quantity, nearly every industrial field where high temperature is required will be invaded.

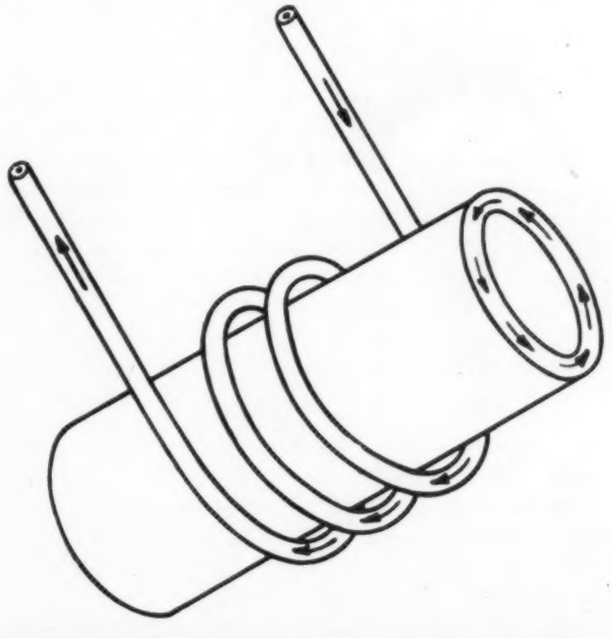
"To the scientist engaged in the study of the properties of matter at high temperature and under controllable chemical conditions, the method of high frequency inductive heating is absolutely indispensable.

"Its future is very bright because it is the most versatile of all known methods of producing temperature and because heat treating materials through wide ranges of temperature, even in tonnage lots, is economically possible. Time is sure to bring engineers and capital to a further recognition of these facts."

Doctor Northrup's predictions have been amazingly accurate perhaps even more so than he expected, for at the time of his predictions, 100 kw was considered to be an extremely large generator capacity.

In the middle 1920's, rotating high frequency generators became commercially available and gave an additional impetus to induction heating. Larger installations were made and, as more data became available, the

Figure 1 — Current relationship between primary and secondary windings.



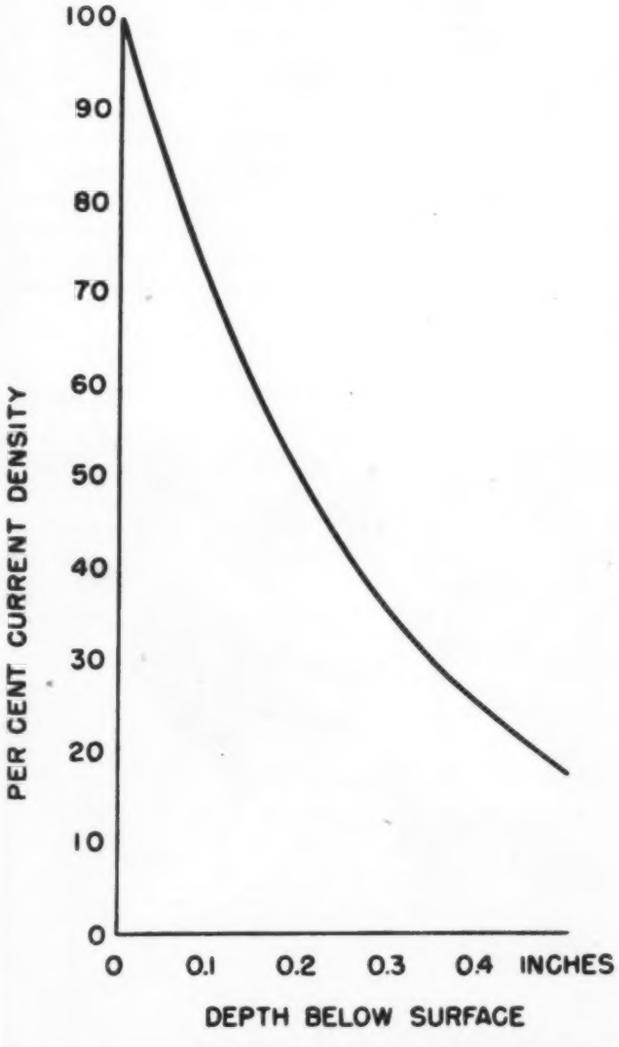
Presented before A. I. S. E. Philadelphia District Section, November 6, 1943.

industry became increasingly active. The early applications were primarily for the melting of special alloys and materials in small furnaces, as the limited generator capacity necessarily prevented large scale installations. The removal of the limitation on generator capacity and the increasing success of induction melting, aroused interest in other uses such as induction heating, surface hardening, heating for forging, brazing, soldering, annealing, tempering, and all types and varieties of heating where a quick controllable heat could have advantages. In the past few years, particularly since the outbreak of World War II, the expansion in the number of installations and the number of uses of induction heating have been tremendous.

The recent rapid growth of induction heating has left many people with the impression that some magical property is involved in its use. Fortunately, that is not true, for the same fundamental laws of heat transfer, transformer ratios and the like still hold true.

An inductor coil and its charge constitute nothing more or less than a transformer having a single short-circuited turn for a secondary winding. The power loss

Figure 2 — Typical distribution of high frequency current flow.



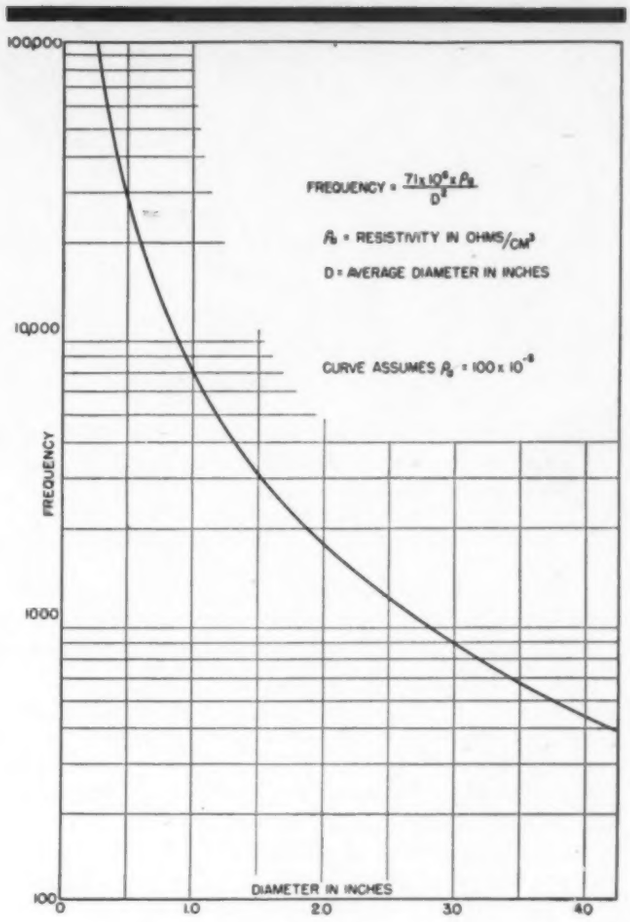


Figure 3 — Base frequency vs diameter.

in this secondary depends upon the current flow and upon the resistance of the winding. If we consider a hollow bar with a surrounding inductor coil (Figure 1), the relationship of the current flow in the primary and secondary windings becomes readily apparent. The flux produced by the current in the primary coil generates an opposing current in the secondary coil although with an air core transformer only a portion of the primary flux will serve a useful purpose.

At low frequencies we encounter two problems in the economical transfer of power:

First, the entire cross sectional area of the bar will carry current and so, for a given I^2R loss, the secondary current must be high.

Second, the effect of this high circulating current is to oppose the flux produced by the primary coil and consequently only a very small percentage of the flux will thread the secondary coil, the remainder finding an easier path outside of the secondary loop.

As we increase the frequency, we overcome both problems. The magnetic forces set up by the circulating current force the current flow to the outside surface and the resulting concentration of current in the surface layer (as shown in Figure 2) greatly increases the apparent resistance of the secondary circuit. Consequently, for a given I^2R loss, we require less secondary current, reduce the amount of exciting flux required and have a more efficient, higher power factor circuit.

If we could have 100 per cent coupling between the inductor and the charge, these factors would not be as

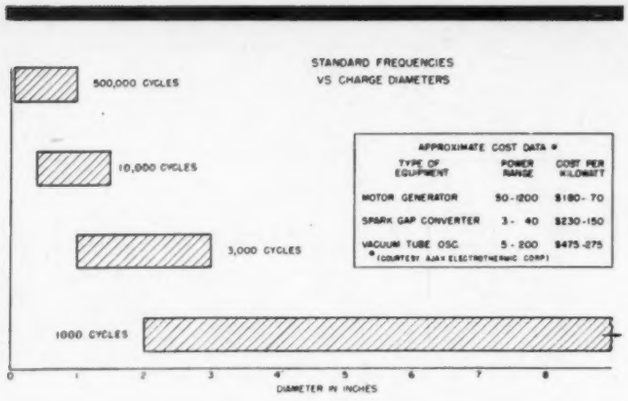


Figure 4 — Field of application of standard frequencies when used for mass heating of steel to temperatures above the critical point.

important, but conditions of operation make this impossible. The power factor of a melting furnace, for example, even at 1000 cycles, will be on the order of 10 to 15 per cent, because the necessity of having thermal and electrical insulation between the charge and the inductor coil means a poor coupling between primary and secondary, and only a small portion of the flux produced by the primary coil is effective in generating current in the secondary circuit.

Depending upon the resistance and dimensions of the charge, there is a base frequency below which both the rate of heating and the efficiency of heating are reduced. Above this frequency, the efficiency remains nearly constant. The theoretical analysis of this fact becomes quite complex, and is of little interest, the important fact being that the use of a frequency considerably higher than the base frequency has no harmful effects.

If we assume a material with a definite resistivity, we can plot the base frequency as a function of the diameter and show the general range of frequency requirements. Figure 3 has been plotted assuming an arbitary value of resistivity, and similar curves could be plotted using different resistance values. It should be remembered that the resistance of the charge increases during the heating period, and consequently the resistance value should be the maximum value during the heating cycle.

In the majority of cases we are concerned with heating materials beyond the critical range and the formula and curves are therefore drawn for a permeability of one. If, however, we are dealing with a magnetic material below the critical range, the base frequency will be considerably reduced, as an increase in permeability is equivalent to an increase in frequency. This is a difficult factor to establish, and must be considered rather carefully because the permeability of a material depends upon the degree of saturation and will vary over a wide range.

It is fortunate that the use of frequencies higher than the base frequency involves no hardship, for it is impossible to attempt to build equipment for each and every frequency that might be involved. With rotating apparatus, these frequencies have been rather well established at 1000, 3000, and 10,000 cycles and, while there appears to be a considerable spread between these frequencies, there is actually quite an overlap in their fields of application. As shown in Figure 4, a 2½ in. diameter bar could be heated with either 1000 or 3000 cycles with little choice to be made between the two.

You may question why the field of application of the various frequencies has been shown as extending to considerably smaller diameters than those shown by the theoretical curve. This is primarily a matter of economics — the higher the frequency, the more expensive and less efficient is the power generating equipment. Economically it is better in some of the border line applications to use a more efficient generator with a lower first cost than to use a higher frequency even though we have somewhat less efficient heating. This is particularly true in cases where the question is between the use of rotating equipment or some type of static high frequency generator. The upper limit for frequencies obtained with rotating apparatus is about 10,000 cycles, and above this frequency the static generators — either the spark-gap type or the vacuum tube power oscillators — must be used. This method of power generation is inherently less efficient and considerably more expensive than rotating apparatus.

Probably the most widely used of the static generators is the vacuum tube oscillator, operating at a frequency of approximately 500,000 cycles. This frequency has been chosen more or less arbitrarily, for while it is sufficiently high for the vast majority of the work in its field, it has the advantage of an operating frequency outside of the regularly assigned radio bands. While the cost of the vacuum tube equipment is high, it is consistent in operation and requires little maintenance.

The power requirements in induction heating vary over a wide range from application to application. If, however, we divide the work into three fields — melting, mass heating, and surface heating — we can make some general estimates that will be of interest.

As a rule, in induction melting the power supply for

Figure 5 — Large induction melting furnace.

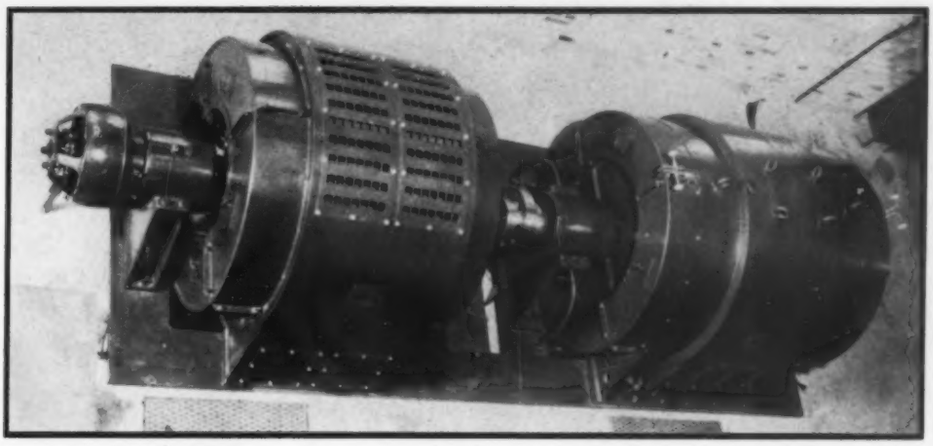
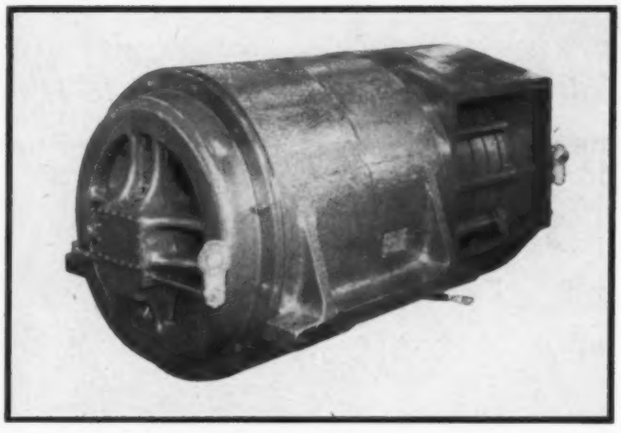


Figure 6 — (right) Frequency changer set with totally enclosed, water cooled generator of 1250 kw, 960 cycle rating.

Figure 7 — (below) Frequency changer set of 200 kw, 3000 cycle rating. Two-units, two-bearing construction with motor and generator rotors on the same shaft.



the furnace is approximately 600 kilowatts per ton capacity. This corresponds to the power required to melt a charge in some 50 to 70 minutes which, for any sizable furnace, is the minimum that is desired. A 5000 lb furnace, for example, is supplied from a 1250 kw generator and melts down in approximately one hour and fifteen minutes. Figures 5, 6 and 7 show typical furnaces and motor-generator sets used in these applications.

As mentioned earlier, the power factor of the furnace load is very low (10-15 per cent); consequently, shunt capacitors are used to maintain a unity power factor load on the generator. Some of the capacitors are permanently installed, while others are added to the circuit as the power factor changes during the heat. Figure 8 shows a capacitor installation with the contactors for adding capacitor units. The use of the high-frequency, together with water cooling, enables each of these capacitor units to be rated 230 kva continuously.

Present day practice will use 3000 cycle power up to about 100 kw and 1000 cycles for larger installations. While the very large units could use a somewhat lower frequency, we again encounter the question of economics.

The cost of generating equipment would be somewhat less at the reduced frequency, but we would increase considerably the cost of the capacitor bank required for power factor correction. The overall savings would be very small and the increased stirring action resulting from the increased circulating current is undesirable. Consequently, 1000 cycles has been an excellent compromise.

In forging work, the power input is necessarily limited by the speed with which the heat developed in the outer skin can be transferred to the body of the piece being heated. For example, in heating a 3 in. diameter steel bar with 1000 cycles, 80 per cent of the heat is developed in a surface skin averaging .3 of an inch thick. Obviously, if we feed power into this surface faster than it can be transferred to the remainder of the bar, we will superheat, or even melt, the surface before the center of the bar is up to temperature. Consequently, we are forced to either use a lower power input over the entire heating cycle or to use a high power input for a short period of time, automatically dropping back to a low power input before we have injured the surface. Both methods are in use and both methods give satisfactory operation.

In a rather typical installation (similar to that shown in Figure 9) where 3 in. bar stock 19 in. in length is being heated to a temperature of 2250 F for forging 105 mm shells, the average power per furnace is 100 kw at a frequency of 1000 cycles, and the heating time is 4 minutes per bar. This length of time, combined with a short period during the transfer of the bar between the heater and the forging machine, is sufficient to give a completely uniform forging temperature. By comparison, a 7 in. square billet requires a heating time of

Figure 8 — Installation of water cooled capacitor units for power factor correction of induction melting furnace.

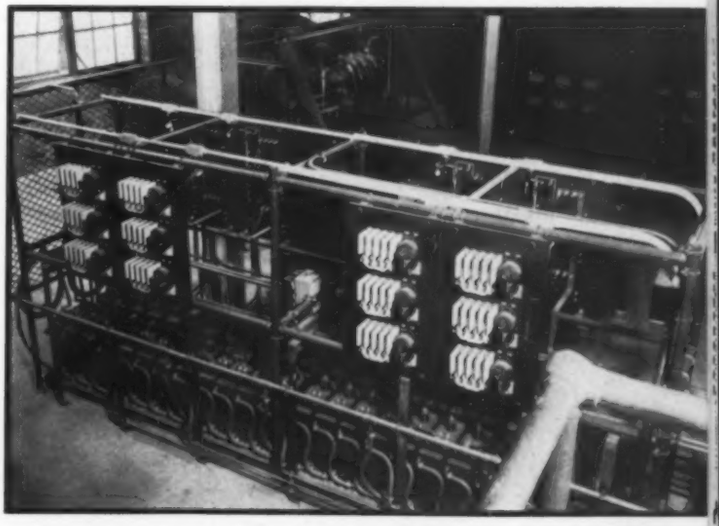


Figure 9 — Inductively heated bar about to be forged. At lower right another bar is being heated.

approximately 15 minutes whereas a 1 in. diameter bar only requires a heating time of 1 minute.

From an efficiency standpoint, it is advisable to keep the heating time as short as possible, as the radiation losses are quite appreciable and any excess time over that required for uniform temperature means increased power loss.

In forging work, as in melting work, shunt capacitors are required to provide a unity power factor load. On small heater units where several heaters are supplied from one generator, sufficient capacity is added to each heater to maintain the overall load at unity power factor, even though the individual heaters pass through a cycle of leading power factor at the start to lagging power factor when the bar is hot. When an individual heater represents a large portion of the generator load, it is often the practice to automatically add additional capacity at definite times during the heating cycle.

The kw load during the heating cycle varies throughout the cycle in the same manner as the power factor, and in order to reduce the required generator capacity, the heater load is generally kept small in relation to the generator size. At times this is impossible, but the recent success of parallel operation of high frequency alternators has been a help in this respect. In one recent installation where four 700 kw, 1000 cycle sets would ordinarily be required to feed the load, the paralleling of three 700 kw sets to give 2100 kw generator capacity on the bus, combined with proper staggering of the heater loads, saved the installation of a complete set.

Both 1000 and 3000 cycles are used in the larger forging work, with little to choose between the two. The length of time to obtain uniform temperature is much the same, for in the one case we develop the majority of the heat in a surface layer 0.3 in. deep while in the other case, the layer is 0.2 in. deep. The conduction of the heat from the surface to the center is the limiting item in either case.

Surface heating, perhaps better known as surface hardening, is quite opposite to forging work, for the entire object is to concentrate the heat in the surface skin with little or no heating of the core. Figures 10 and 11 show typical surface hardened pieces with the heat treated surface and the original core structure, as well as a typical 10,000, cycle motor generator set used in this work.

It is impossible to give any figures on this type of work without danger of contradiction, for we can vary the frequency, the power, the time, the length of the delay period before the quench, the length of the quench, the type of steel, the preheat, and so forth. The results obtained with the use of 10,000 cycles might be duplicated with 500,000 cycles or even 3000 cycles with the necessary shifting of the many variables. While it might be possible to set up general rules for specific sizes and types of pieces, the majority of this work requires experimental work to be sure that the desired results are obtained. Obviously, if the depth of

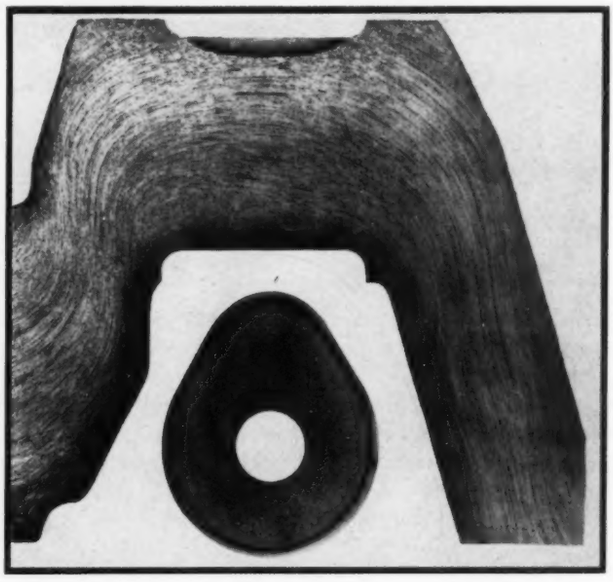


Figure 10 — Surface hardened crankshaft journal and eccentric cam.

▲

Figure 11 — Two-unit, two-bearing frequency changer set of 125 kw, 9600 cycle rating. Mounted on base before assembly into cabinet.

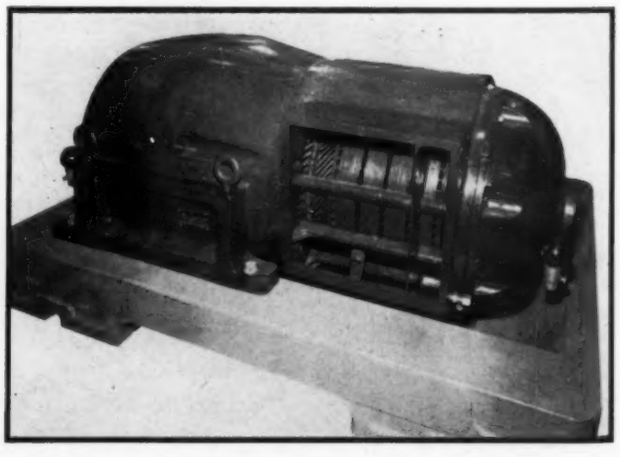


Figure 12 — Contour hardening of small gear with 500,000 cycle power.

hardening is to be high, a frequency of 3000 or even 1000 cycles may be ample, while for very thin cases, even on large diameter pieces, 10,000 cycles or higher may be required.

The choice of frequency in this work is governed not only by the diameter of the piece and the depth of case but also by the possible necessity of closely following an irregular outline. Where contour hardening of gears or similarly shaped objects is necessary or desirable, the high frequencies obtained with power oscillators may be required to give the desired heating pattern. Such an operation is shown in Figure 12.

At the present time it is impossible to predict where the use of induction heating will stop. The three features of cleanliness, controllability, and speed may justify a seemingly uneconomical installation, for where we can save man power or obtain a better product, we can justify considerable expense.

In these new applications, there will be many mechanical and electrical problems to be solved. The equipment with which induction heating is to be used may need to be completely redesigned in order to adapt the equipment to induction heating methods. Special control will be required in many places and it may even be necessary to design new generating equipment to supply the loads. Even so, within the next ten years, many of the present day heating processes will be supplemented, or even replaced, with induction heating.

The power requirements of many of the new applications will be relatively small, but other possible applications may involve a tremendous amount of power. We may replace the present furnaces for the heating of bars and billets with continuous induction heating. There are tremendous possibilities in the continuous annealing and heat treating of steel strip. We may replace the soaking pits for the heating of ingots, or we may provide controlled cooling of all or part of the ingot.

If these possibilities come true, we will undoubtedly see a change in the method of generating and distributing high frequency power. It is not out of reason to consider complete generating stations with turbine-driven high frequency generators, and complete distribution systems very similar to present-day commercial frequency practice.

All of these things are possible, and while the economics of such installations still require considerable study, the progress is in this direction.

Induction heat is neither a cure-all nor a miracle maker; it is merely a method of heating that eliminates many of the disadvantages of other types of heating. Consider it carefully and apply it where its advantages will justify its use.

DISCUSSION

PRESENTED BY

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F. T. Chesnut: In Dr. Northrup's first experiments with high frequency heating, back in 1915 and 1916, he used the mercury-hydrogen spark gap converter, but by the early 20's he had extended his work to include the lower frequencies produced by rotating generating equipment and the higher frequencies produced by vacuum tubes. Electronic heating, as it is widely advertised today, is not so new.

At the present time there are several hundred thousand kilowatts of energy in use for induction heating applications. Over the past years, installations were predominantly for melting but today, by a very rough approximation, it is estimated that about 50 per cent are being installed for melting, 20 per cent for surface hardening, and 30 per cent for other heating applications such as forging, annealing, upsetting and the like.

While vacuum tube operated equipments are receiving considerable attention at the present time, it is estimated that not more than 5 per cent of the total

installed capacity is supplied by tube converters. Tube converters are desirable, and are in fact necessary where very high frequencies are required, but it is not likely that they ever will be a competitor to the motor generator operated equipments for the great bulk of heating applications in industry which require only the lower ranges of frequency.

Vacuum tube converters are not suited for melting operations, as a rule, because the overall efficiency is low, the heat is generated in too shallow a surface layer of the charge, and there is little or no electromagnetic stirring to distribute the heat or mix the charge. In addition to this, the very high frequencies tend to heat the refractory walls as well as the conducting charge, and the capacity effect of persons working around the furnaces makes them subject to bad electrical burns from the high voltage arcs.

Mr. Shaad made one comment to the effect that, above the base frequency, no harmful effect results. I am sure he would qualify that by adding, "within certain reasonable limits," because, as the frequency is increased, efficiencies generally become poorer, the cost of equipment becomes greater and, as I pointed out above, the highest frequencies often times are not applicable at all.

Mr. Shaad has commented on the future of induction heating and I agree with his remarks. I can say very definitely that induction heating is reaching into the smaller foundries where these melting units have heretofore been considered luxury items. The larger melting equipments probably will be extended as alloy steels progress, and it is expected they will be used for duplexing operations. Banks of small melting furnaces appear to be preferred to single large furnaces, although furnaces of 10 tons capacity have been built.

The hardening field probably has about reached the crest of its rise but will continue to expand in the field in which it has found a place. The field of heating for forging, annealing, brazing, upsetting and the like probably has hardly been scratched. It is expected that this field will continue to expand for a long time to come.

L. F. Coffin: I would like to ask whether it is at all practical to use high frequency induction heating for jobbing work; for instance, on large forging machines, where varying diameters of stock and varying shapes of work would be required. As I understand it, high frequency induction heating for forgings is peculiarly adapted to a multiplicity of parts of the same size.

G. E. Shaad: I would say the answer is yes, within limits. You may not have top efficiency and will probably require more generator capacity than that required for an installation operating on a definite piece of material, where with proper scheduling you can continuously hold maximum load on the equipment.

If you are considering a range of diameters of, say, 1½ to 3 inches, it will be perfectly practical for forging work. Some experimental work will be necessary to determine exact results and the coils required, but the job can be done nicely. I believe Mr. Chesnut will agree.

F. T. Chesnut: The cost of the actual heating unit is extremely low, representing considerably less than 10 per cent of the total investment. Once you have the power source, you can adapt almost any kind of heater, experimentally at least, for practically nothing. A good mechanic can make a coil for a particular job out of miscellaneous scrap. Usually, it is not even necessary to cool the coil. Once the shape and turns are known, a more permanent unit can be made.

H. L. Watson, Jr.: I would like to ask a question with respect to the heat treatment of an article such as the gear shown in the illustration. Was it heated in a coil of a particular shape or what is done to prevent concentration of heating on the tips of the teeth?

G. E. Shaad: With certain tooth pitches and certain diameters, you will obtain a very beautiful contour hardening of your gear. Assume we have a particular gear on which we have a good contour effect. If we change to a larger tooth pitch, we may find we no longer have a true contour, but harden only the top and sides of the gear tooth with no hardening between the teeth. Likewise, if we go to a smaller tooth pitch, we may harden the tooth completely.

There is as yet no formula into which we can insert the various parameters and arrive at an answer of 8 kw per square inch at 50,000 cycles to obtain the desired results. At the present time, each gear must have its inductor coil designed by trial-and-error to determine the power requirements and the coil design for a required pattern. A circular coil is used rather than attempting to follow the gear outline.

E. K. Spring: On one of the charts you have a very high frequency figure for one inch rounds. What kind of astronomical figures will you reach when you go to a 16th of an inch?

G. E. Shaad: The curve drawn indicated the frequency for the most efficient generation of heat and the most efficient operation. It does not mean that lower frequencies cannot be used. In the chart showing the field of application, for example, 500,000 cycles can be used for ⅛ in. material. Theoretically, the frequency should be higher, but practically 500,000 cycles will do the job, and the use of the lower frequency involves fewer problems in application, although it is slightly less efficient.

On some work, such as the heating of very small wires for soldering or brazing, we have been forced to frequencies of about 2 megacycles in order to obtain satisfactory heating; 500,000 cycles was too low for this particular work.

E. K. Spring: What is the top limit of the air-gap unit?

G. E. Shaad: Normally about 250,000 cycles.

E. K. Spring: That wouldn't be quite high enough for a small rivet, say?

G. E. Shaad: It would be rather inefficient, but is a border line case.

E. K. Spring: Is there a critical distance where you can best control your heat input from your coil?

G. E. Shaad: The closer the coupling, the better the heat transfer.

E. K. Spring: The closer the coupling, the more efficient, but I want control.

G. E. Shaad: That will depend upon the piece being heated. For example, we may wish to maintain a constant power input to a piece of tubing where the diameter of the tubing varies, say from ½ in. to ⅝ in.; if you have a close coupling, the power input will also vary, being a maximum when the tubing is largest and consequently closest to the coil. In such a case, a more

uniform power input would be maintained if the coil were considerably larger than the tubing, so that the irregularity would have little influence on the circuit characteristics.

If, however, you are speaking of control of power input to uniform material, the degree of coupling has little influence.

E. K. Spring: Is it feasible to use a big inductance coil on any job such as a gear? In experiences I have had in attempting to harden pieces that resembled a gear, using an air-gap machine, I have found I was inducing my highest current at the point most distant from the outer periphery of the gear teeth. It didn't develop the maximum heat at the outside. Is it possible to use a shaped conductor and overcome that?

G. E. Shaad: Frankly, I don't know.

E. K. Spring: I wonder if the advocates of induction heating — and I have an induction machine — aren't going too far? There have been applications of induction heating I have met where they produce enormous hardness of steel when quenched but when we temper it, it flops — and the man doing the job complains, not of the steel, but of the induction heating equipment. Is it possible that they are not allowing sufficient time? Are they attempting to go too fast?

G. E. Shaad: There has been considerable argument along induction hardening lines for the case hardness developed with induction hardening is higher on certain jobs than the theoretical hardness obtainable from the material. Certain steels, for example, may have a theoretical maximum hardness of 60 C, whereas, a piece of this same material, induction hardened, may show a hardness of 64 to 65 C. The theories as to just what happens to the grain structure and the alloy constituents in these cases are not yet proven.

That does not answer your question and, as a general question, I'm afraid it can't be answered. I believe that any particular application in which you encounter this problem could be analyzed and the answer found.

E. K. Spring: In heating some strip, the temperature is in the neighborhood of 1200 or 1300 F — for annealing and for hardening strip of other compositions I want to go, say, to 2300 F. Must I make any distinction in my methods? Must I run higher frequencies for one of those applications than I do for the other?

G. E. Shaad: You can use a much lower frequency up to your critical temperature.

E. K. Spring: How much lower?

G. E. Shaad: About one-tenth frequency. But lets take an example: There are several installations of induction heating for heating electrolytic tin plate to a temperature of 425 F for reflow of the tin coating. With this gauge material, 10,000 cycles (while not too efficient) will heat the strip to this temperature very nicely, but 10,000 cycles is not a high enough frequency to heat the strip above the critical temperature. To go above the critical would require a frequency above 100,000 cycles.

As I pointed out earlier, the effect of your magnetic properties gives the same result as an increased frequency as far as your heating efficiency is concerned. Consequently, 10,000 cycles with magnetic material is the equivalent of 100,000 cycles, or more, with non-magnetic material. As a result, your low frequency will provide heating until the critical temperature is reached, and then as the material loses its magnetic properties, the heating practically stops.

L. V. Black: For some years, I have been under the impression that it was necessary to have a carbon or graphite liner when melting nonferrous metals. Several weeks ago I was advised that it is not necessary to have a carbon or graphite liner. That being the case, what is the difference in the generating equipment, kwhr capacity, capacitors, etc., for melting non-ferrous metals, compared to ferrous metals?

One other point is that of transmission of high frequencies. How far can frequencies of 1000 or 3000 cycles, and capacities of 300 to 500 kw be transmitted? What size conductors and cable spacings should be used?

D. M. Petty: One of the reasons I am anxious to add my few words to the discussion of this paper is that I enjoyed the privilege of counting Dr. Northrup as one of my very good personal friends, and in the early days of high frequency we discussed many times the various applications and possibilities of high frequency electric power.

Mr. Black's question about the transmission of high frequency power in fairly large amounts is one of the questions which Dr. Northrup and I discussed, and we at one time discussed with a cable manufacturer the practicality of a concentric two wire cable with built in capacity to balance the inherent induction of such a cable. I do not know whether such a cable has ever been put into operation, although we were given to understand that theoretically it was entirely within the range of possibilities. At the time of this discussion we were thinking in terms of fairly large power generating units to be located some little distance (say at least 1000 feet) from the point of consumption, such power generating units to be driven by steam turbines or other high speed prime movers.

I believe the use of high frequency current is just beginning to be realized and I rather regret that I cannot join with all the young engineers and scientists in helping to develop this, another very versatile tool for industry. I firmly believe, however, that it will be developed to its full limit and I also know that those who take an active part in this development will have lots of fun because it will give imaginations a chance to run at full speed.

G. E. Shaad: In answer to Mr. Black's question regarding the transmission of 1000 and 3000 cycle power, there are not too many problems involved. We are running 600 kw of 3000 cycle power more than 600 feet, using concentric cable, and there seems to be no reason we cannot go further.

When the time comes for the transmission of large blocks of power, it will require step-up and step-down transformers and much higher transmission voltages. What new problems we will encounter in this work remain to be seen, but I see no reason the problems cannot be solved quite easily.

I am going to ask Mr. Chesnut to answer Mr. Black's question regarding the use of conducting versus non-conducting crucibles for non-ferrous melting work.

F. T. Chesnut: I am going to try to answer the question by saying that practically all non-ferrous metals are melted in clay-graphite crucibles because of

(*Please turn to page 88*)

Pulverized COAL FIRING OF METALLURGICAL *Furnaces*

. . . . reviewing a number of applications of pulverized coal to heating operations in the iron and steel industry . . . .

by L. S. Wilcoxson

THE BABCOCK AND WILCOX COMPANY

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▲ THE past abundance of oil and natural gas, and the facilities for their use, have delayed the use of pulverized coal firing for many purposes where it would unquestionably prove to be the economical fuel.

Many types of metallurgical furnaces now being fired with oil or gas are suitable for firing with pulverized coal, and with the present day necessity for conserving the country's oil supply, conversion of such furnaces from oil firing to coal firing can and should be made. In these conversions, however, it should be borne in mind that the conditions with which we are now faced, while naturally accentuated due to the war emergency, are nevertheless indicative of the possible future fuel situation in this country. The estimated oil reserves from recent statistics are believed to be sufficient for only 13 to 14 years at the 1941 rate of demand, and with the rate of discovery of new oil reserves being considerably less than current consumption, it would seem to be inevitable that even if the number and potential production of new discoveries increases materially over what they have been for the past few years, there will necessarily be increased exploration and production costs that will result in price increases for all grades of oil to the ultimate consumer.

It is also true that when the time of diminishing oil reserves arrives, whether or not the present estimates of that situation already being with us are correct, the alternative sources of oil supply through the treatment of oil shales, coals and other carbonaceous materials will involve recovery expenses greater than those involved in the treatment of crude petroleum. Consequently, no matter how one views the fuel oil situation for the future, there are definite indications that the cost of liquid fuels will rise, probably rapidly, with respect to the cost of coal. For minimum fuel costs, therefore, it is by no means too early to be thinking of the basic industrial fuel of the future.

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PULVERIZED COAL FIRING

It is only logical that an operator having many years experience with oil or gas firing of furnaces, upon consideration of changing over to pulverized coal, will raise, among others, three very pertinent questions:

1. Can pulverized coal be employed with a facility equal to that of oil or gas as a fuel?
2. What effect will the use of pulverized coal have on the products from the furnace when they must be controlled within relatively narrow specified limits?
3. What are the comparative economics of pulverized coal firing as against oil or gas firing?

The answer to the first question is that pulverized coal can be employed with equal facility to oil or gas as fuels. It is true that more equipment must be installed at the plant site with pulverized coal than with either oil or gas, but the equipment involved, such as coal unloading, storage and conveying equipment, together with the pulverizer and distributing lines

therefrom, can and should be so arranged as not to interfere with operations being performed around the furnace where the coal is to be burned, as well as to function smoothly with respect to the supply of pulverized coal to the burners as required, with the minimum amount of attention from the operators. Details of such installations are given later.

With respect to the second question, it is possible that the use of pulverized coal will have favorable, the same, or detrimental effects on the products from the furnaces where it is being used, as against oil or gas previously employed, dependent largely upon the care exercised in the selection of the coal to be used. Coal is a heterogeneous substance. It is, as we all know, classified in the broad divisions running from the younger deposits of lignite through sub-bituminous, bituminous, semi-bituminous and anthracite, but coals in any one of these divisions may vary widely in specific composition and analysis. It is quite necessary, therefore, to determine and maintain a specification of the coal to be used within the limits dictated by the combustion requirements of the product from the furnace, if the best and most beneficial results are to be consistently maintained.

The characteristics of the coal most important from the viewpoint of operation of metallurgical furnaces in their order of importance are:

a. Fusing temperatures of the coal ash, particularly initial deformation temperature.
b. Ash content of the coal.
c. Sulphur content of the coal.
d. Volatile content of the coal.
e. Grindability of the coal.

Fusing temperature of the coal ash — The initial deformation temperature of the ash in the coal is of paramount importance, and must be considered carefully with respect to the furnace operation. For example, if the furnace under consideration for pulverized coal firing is a billet heating furnace, heating rounds for subsequent rolling operations, and the steel or alloy being heated must be discharged from the furnace and fed to the rolls at 2350 F plus or minus 25 F, it will be obvious that in order to avoid slagging in the furnace, with slag on the billets which might interfere with subsequent treatment, the initial deformation temperature of the ash in the coal must be higher than the maximum temperature required in the furnace—or, in a case such as this example, an initial deformation temperature of the coal ash on the reducing basis in the neighborhood of 2500 F or higher. (See "Significance of Coal-Ash Fusing Temperature in the Light of Recent Furnace Studies," by E. G. Bailey and F. G. Ely, A. S. M. E. Fuels Division, December, 1940.) On the other hand, should the furnace in question be a large forge heating furnace, in which the deposition of some slag from the coal ash on the scale on the ingots would not be objectionable, or a furnace in which the metal is in a molten condition covered by a layer of slag, such as an open hearth furnace, then there would be no detrimental effect from the ash of the coal if in a liquid state, in so far as physical conditions are concerned. Consequently, a coal having a much lower ash fusing temperature could be employed.

Ash content of the coal — The ash content of the coal is decidedly of secondary importance and is of itself only important because it constitutes inert material put into the furnace with the fuel which must ultimately be disposed of. In a dry ash furnace, such as the billet heating furnace mentioned previously, a certain portion of the ash resulting from the combustion of the pulverized coal will be deposited in the furnace, while the balance will be carried out of the furnace with the combustion gases to be deposited in flues and ducts, with some percentage of it being discharged with the gases from the stack. The furnace must, of course, be cleaned periodically, as also must the flues and ducts, and obviously the smaller the quantity of ash present, the longer can be the periods between cleaning, or the shorter will be the time required for cleaning if the periods are maintained constant. It is quite feasible in many dry ash furnace operations to clean the furnace hearth, etc., during operation, which procedure under certain circumstances has its advantages in improving continuity and uniformity of operation.

Sulphur content of coal — The sulphur content of the coal is of variable importance, being dependent upon the heating performance required of the pulverized coal firing, although in general, the lower the sulphur content the better. A factor of considerable importance in connection with the sulphur content is the degree of fineness of pulverization, as in general the finer the pulverized coal burned, the greater the percentage of the sulphur present that passes away in gaseous form depending upon furnace operating conditions.

Volatile content of the coal — Upon the volatile content of the coal depends the ease of ignition and maintenance of combustion, but the allowable range is relatively wide, as, for example, between 20 and 36 per cent. While a coal of 32 to 34 per cent volatile matter would under most circumstances be the most desirable, any requirement for a particular percentage within the range specified is of little importance as compared to the fusing temperature of the ash and the sulphur content of the coal.

Grindability of the coal — The grindability of the coal determines the amount of work to be done in the pulverizer to attain a specified capacity and fineness of pulverized coal, and is therefore an important basis upon which the pulverizer is designed to meet the requirements of any particular application. The pulverizer capacity with a constant fineness of product is generally directly proportional to the grindability of the coal being pulverized. Beyond its effect on pulverizer performance — either as to capacity or fineness or both, as they are naturally inter-related — the grindability of the coal is of significance because of its relationship to the specific surface of the pulverized coal produced. In general there are indications that the higher the grindability the higher the specific surface produced at a given mesh screen analysis.

With a coal available for use within the limits of specification as outlined briefly above, the pulverizer installation should be designed to provide the capacity requirements at a high degree of fineness, in the neighborhood of 90 per cent or better through 200 mesh screen. The importance of high fineness, to which reference has been made previously, cannot be overemphasized, as to this factor alone can probably be attributed the difference between success and failure of certain applications of pulverized coal firing. Certainly, in the

TABLE I

Comparison Between Pulverized Coal and Oil Firing Billet Heating Furnaces

	21,700,000 Btu		108,500,000 Btu	
Method of firing	Pulverized coal circulating system	Oil	Pulverized coal circulating system	Oil
Heating value of fuel	14,160 Btu per lb	150,000 Btu per gal	14,160 Btu per lb	150,000 Btu per gal
Cost of fuel delivered in plant	$ 5.50 per ton	$ 0.0621 per gal (=$2.60 per bbl)	$ 5.50 per ton	$ 0.0621 per gal (=$2.60 per bbl)
Cost of fuel per million Btu	$ 0.196	$ 0.414	$ 0.196	$ 0.414
Capital expenditure				
Fuel storage and handling	$20,500.	$18,500.	$20,500.	$34,500.
Fuel preparation and burning	$18,000.	$ 8,000.	$60,000.	$36,000.
Total capital investment	$38,500.	$26,500.	$80,500.	$70,500.
Fuel per year 300 days, 24 hrs per day	5500 tons	24,800 bbl	27,500 tons	124,000 bbl
Cost of equipment per ton of coal per year	$ 7.00	.....	$ 2.93	.....
Equivalent cost of equipment per bbl of oil per year	$ 1.55	$ 1.07	$ 0.65	$ 0.57
Estimated operating expenses per year				
Fuel cost	$30,456.	$64,685.	$152,280.	$323,415.
Handling coal storage pile	.....	.....	$ 1,000.	.....
Labor cost	$ 5,760.	$ 1,920.	$ 5,760.	$ 1,920.
Power cost	$ 2,520.	$ 441.	$ 6,798.	$ 2,205.
Steam cost	.....	$ 397.	.....	$ 1,983.
Maintenance	$ 138.	$ 42.	$ 688.	$ 209.
Depreciation (Buildings 30 years, machinery 15 years)	$ 2,236.	$ 1,542.	$ 5,034.	$ 3,947.
Interest — assumed 5 per cent on investment	$ 1,925.	$ 1,325.	$ 4,025.	$ 3,525.
Taxes — assumed 1.5 per cent on investment	$ 578.	$ 398.	$ 1,208.	$ 1,058.
Total operating expense, maintenance, depreciation, interest and taxes	$43,613.	$70,750.	$176,793.	$338,262.
Savings in operation per year using coal instead of oil	$27,137.	.....	$161,469.	.....
Return on investment in coal handling and burning equipment after all operating charges, maintenance, depreciation, interest and taxes, per cent per year	71		200	

early days of pulverized coal firing when a true appreciation of the value of high fineness was not fully realized, and the means of obtaining it were not available, the lack of necessary fineness, or conversely, the coarseness of the pulverized coal as fired, was unquestionably largely responsible for the lack of success that was frequently encountered. The true significance of high fineness can probably best be illustrated by consideration of the fact that with one type of pulverizer pulverizing coal having a grindability of 65, the specific surface as determined by the Lea-Nurse permeability method at 70 per cent through 200 mesh is 3400 sq cm per gram, while the same coal at 95 per cent through 200 mesh has a specific surface of 9000 sq cm per gram.

When these necessary conditions as to coal specification and fineness requirements are met, pulverized coal can be utilized in firing many types of metallurgical furnaces without in any way adversely affecting the product in terms of its specification based on oil or gas firing.

ECONOMICS OF PULVERIZED COAL AS COMPARED WITH OTHER FUELS

A comparison of the economics of pulverized coal firing as against oil firing naturally involves a great number of factors, all of which have distinctly modifying results on the conclusions drawn, such as the size of the installation being considered, its location with respect to coal and oil supplies, etc. It has been considered best for purposes of illustration of the fundamentals involved to predicate economic calculations on both a relatively small installation and a relatively large installation, with fuel, power and labor costs at average figures, but which can be adjusted to meet the specific conditions existing with any particular installation being considered.

That the raw coal handling and conveying equipment forms a considerable part of a pulverized coal installation is amply illustrated by the data in Table I. In this tabulation economic comparison has been made on the basis of a direct fired circulating system for the pulverized coal as being, in general, the most economical application of pulverized coal to meet metallurgical furnace conditions as commonly encountered in the iron and steel industry. The item of raw coal handling and conveying equipment forms a greater percentage of the initial capital expenditure with smaller capacity installations than with those of larger capacity, and it is for this reason that both small and large installations have been taken as bases of comparison, the small installation being representative of a billet heating furnace burning approximately 1500 lb of coal per hour (21,700,000 Btu per hour), and the larger installation being equivalent to five such furnaces, and having the same coal handling equipment up to the feeding of raw coal to the pulverizers.

The fuel costs assumed in this tabulation (coal at

$5.50 per ton delivered and oil at $2.60 per barrel delivered) are average, but the calculations given can be modified to suit the conditions prevailing at any particular time at a specific locality, and as fuel cost is naturally the largest single item of operating cost, the overall economic balance as between coal and oil firing can be readily determined. It will be observed, however, that with the average fuel costs assumed the smaller installation shows a return of 75 per cent per annum on the investment for all coal handling and burning equipment after all charges have been allowed for, while the larger installation shows a corresponding return of 200 per cent per annum. These figures are generally representative of a great number of studies that have been made on conversion jobs within the past year or so, and it can be stated with confidence, therefore, that where pulverized coal firing is applicable to metallurgical furnace use it can be employed with considerable advantage in so far as the general economics of the situation are concerned.

METHODS OF PULVERIZED COAL FIRING

With the foregoing fundamentals in mind, the application of pulverized coal to specific metallurgical furnaces can be considered. There are three types of pulverized coal systems, any one of which might be employed, dependent upon surrounding circumstances, and which in chronological order of development are:

1. Storage or bin system.
2. Direct fired unit system.
3. Direct fired circulating system.

Storage or bin system — The storage system is the earliest form of application of pulverized coal firing, and involves a pulverizer plant operating under essentially base load conditions for a sufficient number of hours per day to supply pulverized coal in storage bins in a quantity sufficient to meet the plant's daily requirements. The pulverized coal is normally fed from a storage bin adjacent to the pulverizers by means of an air transport system to smaller individual storage bins adjacent the burners, to which the coal is to be supplied. From these storage bins the coal is fed by means of a feeder into a stream of primary air and the mixture delivered to the burners, by which, with the addition of secondary air, combustion is attained in the furnace. Such installations have been made, and are still in operation, on a number of forge furnaces in the iron and steel industry, while in the non-ferrous industry a number of copper reverberatory furnaces are so fired. This system has the disadvantage of high initial capital expenditure for the necessary equipment involved, as well as an operating disadvantage in that the pulverized coal, on being separated from its stream of carrier air when delivered to the storage bins, is apt to pack and snowball, and thus interfere with combustion efficiency. It has been largely superseded in recent applications of pulverized coal firing by the direct fired system, which, with its modified circulating system, forms the basis of the present discussion.

Direct fired unit system — In the direct fired system of pulverized coal firing the burner lines are taken directly from the pulverizer, so that the air used through

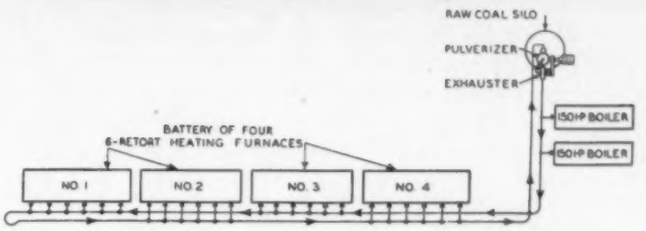


Figure 1 — Typical pulverized coal direct-fired circulating system.

the pulverizer to pick up the coal pulverized therein constitutes the primary air for combustion, while secondary air from another source is added at the burners to complete combustion. The great advantage of the direct fired system is its simplicity and minimum of equipment involved, as compared with the storage system previously referred to, as well as the ability in direct firing to keep the finely pulverized coal separated from the point of pulverization to the point of use, by its continued suspension in air. This system does, however, necessitate the location of the pulverizer reasonably close to the point of use of the pulverized coal in order to avoid unduly long burner line connections and attendant losses in pressure drop and resulting power requirements, as well as burner requirements essentially consistent with rated pulverizer output. In other words, for metallurgical or other furnaces having a Btu requirement in the neighborhood of a given pulverizer capacity, a direct fired system can be used to advantage. A further requirement is that there must be a location available adjacent to the furnaces being fired for the installation of the pulverizer with its drive, fan, raw coal bin and raw coal handling equipment.

Direct fired circulating system — A direct fired circulating system has been developed more recently to meet the requirements of multiple furnaces of small capacity, which present conditions outside the zone of economic application of the direct fired system, while at the same time maintaining the advantages of a direct fired system. These conditions, incidentally, are particularly prevalent in the metallurgical industry, consisting of large numbers of small furnaces having small individual heat requirements, and often so spaced that there is a considerable distance between the furthermost furnaces of a group. Very frequently such furnaces are of such a nature as to their installation and use that there is no space available in their immediate vicinity for the installation of a pulverizer and its appurtenant equipment.

To meet these conditions the direct fired circulating system has been designed so that the pipe carrying the pulverized coal and its primary air is in the form of a continuous loop, arranged so that the loop extends adjacent to the furnaces to be fired, and also to some convenient location away from the furnaces where the pulverizer and its component equipment can be installed as an integral part of the loop, and yet avoid any interference with operation of the furnaces. The loop can be of any length up to 1000 ft or more, and as many burner lines can be taken from it as there are

burners to feed, with a low limit on individual burner capacity for general purposes of less than 50 lb of coal per hour. Each burner can be turned on and off as required. The pulverizer is automatically controlled so that it supplies pulverized coal to the continuous loop at the same rate as it is being fed to the burners at any particular moment, thus resulting in the maintenance of a substantially constant pulverized coal and air supply in the circulating line.

Figure 1 illustrates diagrammatically the layout of a direct fired circulating system, from which the relationship of the pulverizer to the circulating system can be clearly seen. The ease and flexibility of operation of such a circulating system is best illustrated by the fact that its operation and performance is closely analogous to that when gas is used as a fuel.

INSTALLATIONS ON METALLURGICAL FURNACES

By way of example of applications of pulverized coal firing to metallurgical furnaces, a number of specific installations will be illustrated and described.

Semi-direct system of pulverized coal firing reheating furnaces — Figure 2 shows a semi-direct suction system of firing pulverized coal to two reheating furnaces at a steel plant in the Pittsburgh district. There are two furnaces, each of which is 16 ft wide x 8 ft high x 35 ft long, employed for reheating ingots from 1800 F to 2600 or 2700 F. Each furnace is capable of heating 11 ingots per hour. each ingot weighing 3 tons, the heating requirement being 1,500,000 Btu per ton. To meet these heating conditions with coal from Allegheny County, Pennsylvania, having a grindability by the Hardgrove method of 54, and a heating value of 13,640 Btu per pound, the two furnaces are supplied with pulverized coal from a pulverizer which provides 7260 lb of coal per hour at 54 grindability at a fineness of 80 per cent through 200 mesh, with maximum surface moisture of 8 per cent and with primary air at 205 F admitted to the pulverizer.

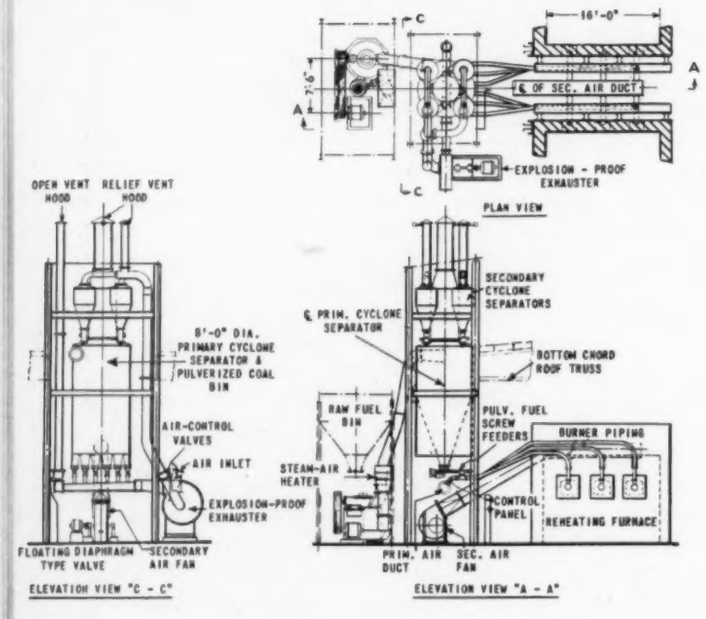


Figure 2 — Semi-direct suction system showing arrangement of pulverizing, storage, feeding and firing equipment for firing two reheating furnaces with pulverized coal.

In the operation of this installation pulverized coal from the pulverizer is drawn into the primary cyclone separator, which also serves as the pulverized coal bin. There are four secondary cyclones, each individually connected to the primary cyclone outlet. The exhauster, which is constructed to withstand explosion pressure, draws the pulverized coal and primary air from the pulverizer through the primary and secondary cyclones and discharges the air into a common primary air manifold header, with six outlets connecting to the burner piping through mixing tees. In cases where an excess amount of primary or system air is available over the requirements for successful burner operation, the excess supply is discharged to the atmosphere through a special floating diaphragm pressure reducing valve and the open vent piping. The system is designed for approximately 10 per cent venting at maximum capacity.

These furnaces are operating wet bottom, with continuous slag removal. In other words, on the basis of coal specifications, this is an instance where there is no great necessity for a close control on the fusing temperature of the coal ash, and where actually a low fusing temperature ash coal is of advantage rather than being detrimental.

Continued operation of this installation since 1936 has proven the refractory maintenance of the furnace with pulverized coal to be normal, being comparable to or slightly better than corresponding conditions prevailing with comparable furnaces fired with oil. The time of individual heats is between 1½ and 2 hours. All ingots heated are wrought iron, on which there is a coating of molten slag during the heating operation. The ash from the coal has no deleterious effect on the ingots during or subsequent to the heating process. The molten ash or slag from the ash in the coal, as well as the slag from the ingots, is removed from the furnace continuously in molten condition. The ash from the coal passing out of the furnace with the combustion gases has not caused any difficulties, the flues and ducts connecting the gas outlets from the furnaces with a 60 ft stack being cleaned periodically of the dry and finely divided ash deposited therein.

Direct firing of pulverized coal in malleable iron melting furnaces — Figure 3 illustrates the application of direct firing pulverized coal to two malleable iron melting furnaces, each of which has a capacity of 27 tons of iron per heat, the heating cycle being 8 hours, and the period between cycles three hours. Each of the furnaces is supplied with pulverized coal by its own individual pulverizer which supplies 3000 lb of coal per hour when pulverizing West Virginia coal having a 55 grindability, 8 per cent surface moisture, and a heating value of 13,500 Btu per pound to a fineness of 80 per cent through 200 mesh. This particular installation, which is in the midwest, was put into operation during 1937, and has been giving satisfactory performance since that date. This, again, is a situation where the fusing tem-

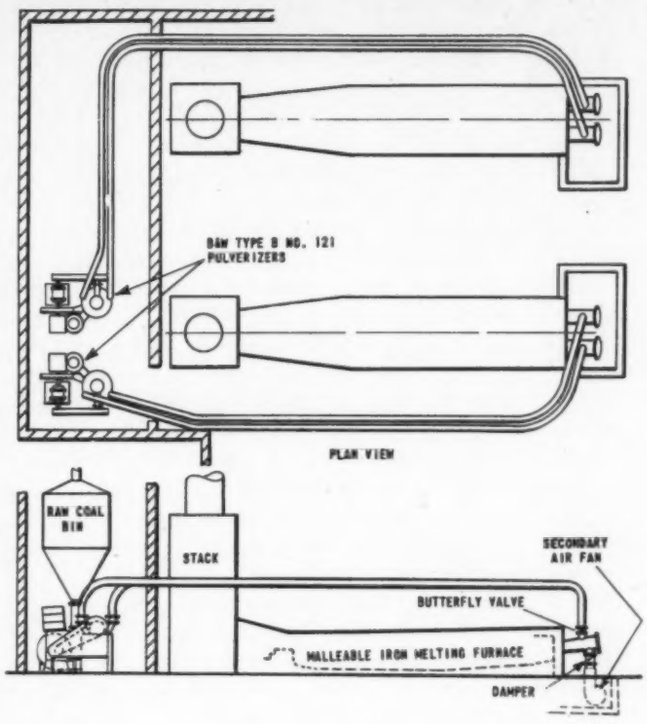


Figure 3 — Direct-fired system firing malleable melting furnaces with pulverized coal.

rature of the ash in the coal is not of primary importance, because of the molten condition of the bath being heated. The average melting furnace performance is as follows:

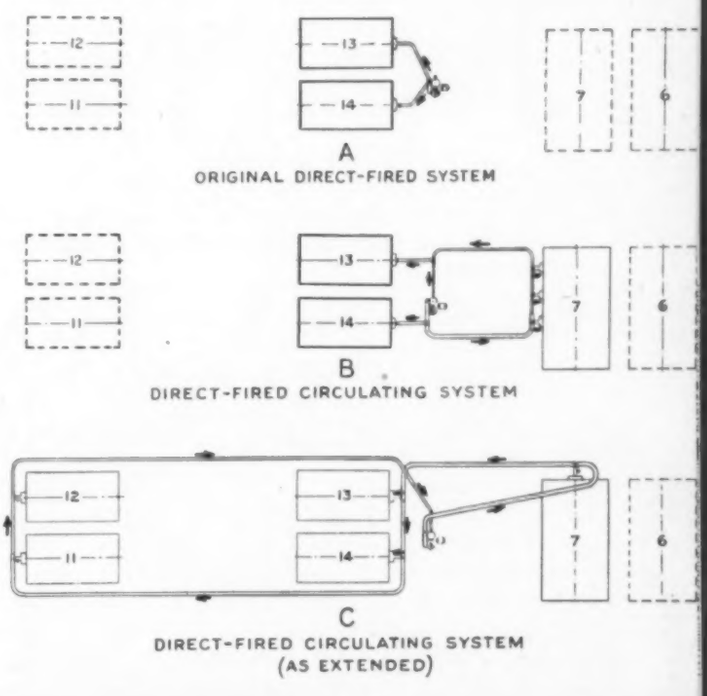
Weight of first charge	24 tons
Weight of second charge	24 tons
Total for two heats	48 tons
Melting time first heat	8 hours
Melting time second heat	5 hours
Average fuel ratio based on two consecutive heats	2.7 to 3 tons of iron to 1 ton of coal.

Maintenance on both furnace and pulverizer equipment has been normal. It is interesting to note that while the Btu requirements of these furnaces tied in well with pulverizer capacity, and amply warranted the direct fired system, the nearest location to the burners where the pulverizer could be installed required burner lines approximately 100 ft in length with four 90 degree bends between the pulverizer and the burners.

Pulverized coal direct firing of malleable annealing furnaces — Figure 4 shows an interesting development in connection with pulverized coal firing of some malleable annealing furnaces. At this particular malleable plant, which is located in the New England district, there are 11 annealing furnaces located in one furnace room, 6 of these furnaces being indicated in the three arrangements, A, B and C of Figure 4. The arrangement shown by A represents the original installation of direct firing pulverized coal in which a single pulverizer was employed to direct fire two annealing furnaces, firing only one furnace at a time. Each of these furnaces has a capacity of approximately 15 tons of malleable iron castings per heat, the heating cycle being 76 hours and the period between the cycles also being 76 hours, so that by staggering the heating and cooling periods of the two furnaces the pulverizer was operated essentially continuously. The pulverizer has a rated capacity, with coal having a grindability of 70, of 830 pounds per hour at a fineness of 85 per cent through 200 mesh, while it actually supplied the heating requirements of the furnace, which amounted to 300 lb of coal per hour, with pulverized coal having a fineness of 95 per cent through 200 mesh. In this installation it was possible to locate the pulverizer close to and about equidistant between the furnaces to be fired, resulting in simple and short burner line connections between the pulverizer and the furnaces.

Direct fired circulating system firing malleable annealing furnaces — With the obvious over-capacity available in the pulverizer, as indicated by the figure given above, the original direct fired arrangement involving the two annealing furnaces was converted to a direct fired circulating system, and an additional annealing furnace having approximately twice the capacity of either of the two furnaces already being fired was added to the system and supplied with coal from the same pulverizer installation. The layout of this direct fired circulating system is shown by B of Figure 4. In making this conversion the larger furnace was converted from hand firing to pulverized coal firing by the addition of three side burners. The results were gratifying, in that the time of the heating cycle was drastically reduced, with a reduction in the coal required to anneal a charge of malleable castings. The time-temperature relation-

Figure 4 — Direct-fired circulating system serving annealing furnaces.



ship for both hand firing and pulverized coal firing is illustrated in Figure 5. It would be possible to obtain a decidedly higher fuel ratio on this furnace with pulverized coal firing at some sacrifice in the time saved on the heating cycle, but with the existing plant requirements, the importance of increased production with moderate fuel economy takes precedence. It will be noted that as against a firing period of 195 hours with hand firing, and a fuel ratio of 2.7 tons of castings per ton of coal,

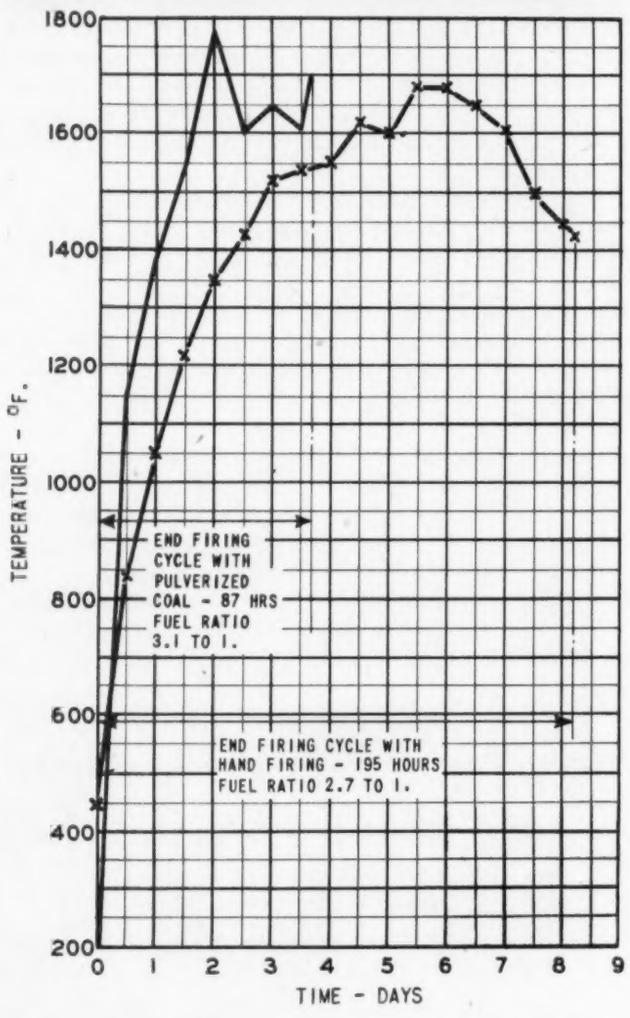


Figure 5 — Time-temperature curves for hand firing and pulverized coal firing of 30 ton malleable iron annealing furnace.

with pulverized coal the firing period was reduced to 87 hours, with an improved fuel ratio of 3.1 tons of castings per ton of coal. With this firing arrangement any combination of furnace operating cycles was satisfactorily accomplished.

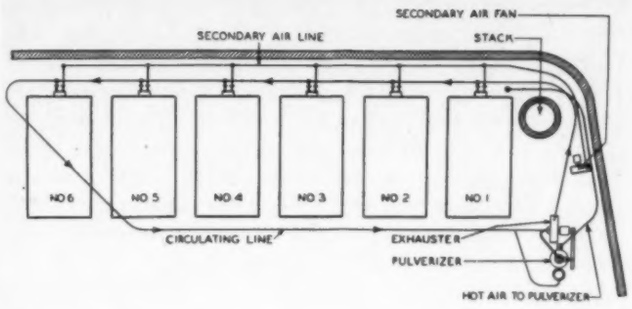
Subsequently, this direct fired circulating system was further extended, as shown at C of Figure 4, to incorporate two additional annealing furnaces, each having a capacity equivalent to each of the original direct fired furnaces, and this system has been in satisfactory operation since December, 1942. The pulverizer is the same mill used for the original direct fired installation, although the fan was modified to give a greater static pressure to overcome the increased resistance in the extended circulating line, and a larger motor was installed. As staggering of the heating and cooling periods of the five furnaces being fired by this circulating system is desirable from the standpoint of normal economical operation of the plant, the five furnaces are seldom, if ever, at the maximum firing rate at the same time, and consequently any normal combination of furnace heating cycles can be satisfactorily handled. In this particular application the maximum temperature to be attained in the annealing pots is in the neighborhood of 1700 F, so that the maximum furnace temperature is in the neighborhood of 1800 to 1900 F. With these temperature conditions it is necessary that the coal should have a minimum ash fusing temperature of above 2200 or 2300 F, in order that there will not be any tendency to form slag in the furnace, particularly as the furnace is operated with a slightly reducing atmosphere. Using coal having this range of ash fusing temperature, the ash deposited in the furnace from the pulverized coal being burned is in dry condition, and is readily removed between the heats.

This installation of direct fired circulating system of pulverized coal firing has proved so satisfactory, both from the standpoint of operation and economics, that a second circulating system to fire the remaining six annealing furnaces is now being installed. Figure 6 shows the arrangement of the new system.

Direct fired circulating system firing billet heating furnaces — Another installation in which the fusing temperature of the coal ash is of paramount importance is illustrated in Figure 7, which shows a direct fired circulating system firing pulverized coal to a continuous billet heating furnace. This installation has been in operation at the Beaver Falls, Pennsylvania, plant of the writer's company since December, 1942.

The billets heated in this furnace vary in size and composition, the steels ranging from low carbon steels to high alloys, such as 27 chrome and 18-8-S. Temperature regulation of the billets being discharged from the furnace to the piercing mill is of utmost importance, with a relatively narrow range of plus or minus 25 F for heats of a specific composition, but with maximum temperature limits, inclusive of all grades of steel being heated, of between 2000 F and 2400 F. As the furnace might, at one extreme, be used for heating one grade of steel over a considerable period of time, and thus have definitely stabilized operation in so far as temperatures are concerned, it might, at the other extreme, have small heats of different steels in rapid succession, requiring burner adjustments for specific temperature regulation to meet each definite steel temperature requirement.

Originally this furnace was fired with a combination of oil and gas, the average consumption being about 2400 gallons of oil per day burned through two oil burners at the billet discharge end of the furnace, and approximately 144,000 cu ft of natural gas per day burned through 16 small gas burners, arranged 8 each side of the furnace. On converting to pulverized coal firing, the pulverized coal circulating system was arranged as shown, to supply the two main burners at the billet discharge end of the furnace, and 8 smaller burners, 4 on each side of the furnace. The fuel requirements of this furnace amount to approximately 1800



lb of pulverized coal per hour. The coal is from Mingo County, West Virginia having a grindability of 45 at a fineness of 95 per cent through 200 mesh.

The problem of dealing with coal ash in this furnace has been satisfactorily solved by the careful selection of the proper coal for the application, together with relatively simple additions to the furnace construction to permit the ready handling of the ash deposited therein. In order to insure operation with all possible operating temperature conditions, and that all of the steel billets be heated with dry coal ash conditions in the furnace, West Virginia coal having a high ash fusing temperature and low ash and sulphur content is employed. A typical coal analysis is as follows:

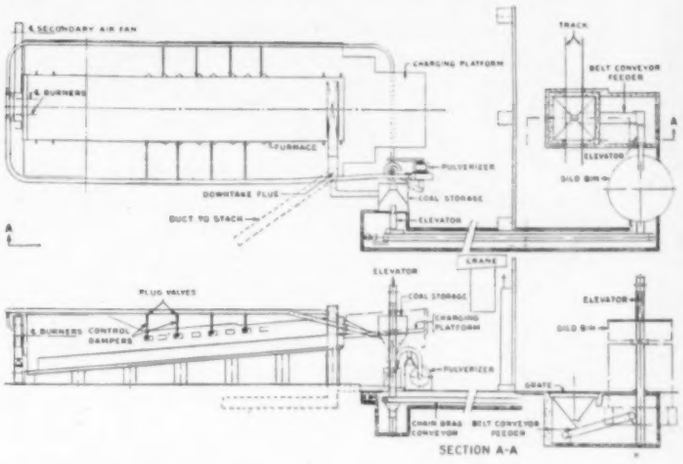
Proximate analysis	*No. 6 mine, Alma seam, Mingo County, West Virginia*
Air dry loss of 95 F	3.4
Total moisture	4.8
Volatile matter	34.6
Fixed carbon	59.4
Ash	6.0
Sulphur	0.6
Btu per lb of dry coal	14,440
Btu — Moisture and ash free	15,360
Grindability — 16-30 mesh fraction	44

Fusion temperatures	*Atmosphere* *Reducing*	*Oxidizing*
Initial deformation	2580 F	2630 F
Softening temperature	2710 F	2730 F
Fluid temperature	2780 F	2840 F

It will be noted that the ash fusing temperatures given above are well above the maximum billet temperature and also the furnace operating temperature required in this furnace, so that consequently the ash liberated upon combustion of the coal is maintained in the dry state throughout the full range of operating temperatures of the furnace. Part of this ash is deposited on the furnace hearth and roof, and also on the billets, but being in the dry state it is readily removed from the billets as they are rolled down through the furnace, and does not, therefore, interfere in any way with normal furnace operation. It is quite obvious, of course, that in a furnace of this type a coal having a low fusing temperature of ash would be extremely undesirable, as the deposition of a molten slag from the ash of the coal on to the billets and furnace floor might result in various difficulties.

Figure 6 — Direct-fired circulating system for pulverized coal firing in malleable heating furnaces.

Figure 7 — Direct-fired circulating system on heating furnace.

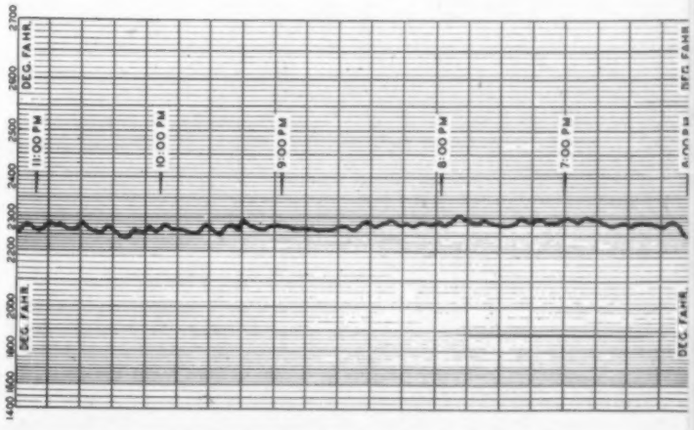


To eliminate any nuisance from ash in the atmosphere around the furnace due to operation with positive pressure in the furnace, hoods were installed over the furnace openings and connected to a duct system through which the gases pass to an exhauster and thence to a stack outside of the building. For periodic cleaning of the ash deposited in the furnace, whether during operation or during a shutdown period, hoppers were installed under each cleaning door to catch the ash removed during the cleaning operation, the ash then being discharged from the hoppers directly to a water-sluicing duct for disposition.

With these few relatively simple precautions the heating and economical advantages of pulverized coal are being fully realized in this installation with satisfactorily clean operation.

As illustrative of the constancy of temperature when firing this furnace with pulverized coal, Figure 8 shows

Figure 8 — Temperature record from billet heating furnace fired with pulverized coal by a direct-fired circulating system.



a short section of temperature chart indicating furnace temperature at the billet discharge end of the furnace, as recorded by a radiation pyrometer. During the particular period covered by this chart, 6 P.M. to 11 P.M., a single row of low nickel chrome billets, each 3 in. in diameter x 73 in. long, and weighing approximately 150 lb, were being heated in the furnace, the temperature required being between 2250 and 2300 F. On this particular installation the two large burners at the discharge end of the furnace, through which the major quantity of coal is fired, are electrically controlled by means of hand selectors on the main control panel, so that the operator can control the rate of coal firing and the heating of the furnace from the control board without any manual adjustments of the control valves in the burner lines. It will be possible to eliminate even the hand selector on the control panel, and have the control actuated directly by temperature, employing the radiation pyrometer as at present installed, and this further step of control may subsequently be taken.

The raw coal handling equipment installed on this job is of interest particularly in view of the extension of pulverized coal firing that was subsequently undertaken, and to which reference will be made later. It will be noted from Figure 7 that the raw coal is delivered from a track hopper by means of a belt conveyor feeder having a magnetic separator, to an elevator which discharges the coal into a 250-ton silo bin, the maximum rate of conveying being 25 tons of coal per hour. The raw coal from the silo is fed by means of a drag conveyor to an elevator, which feeds a 6 ton storage bin above the pulverizer, the maximum rate of feeding of this conveyor being 10 tons of coal per hour. The feed from the pulverizer storage bin to the pulverizer is automatically controlled by the pulverizer feeder controller, which feeds the coal to the pulverizer in proportion to the primary air being admitted. The feeding system from the silo to the pulverizer storage bin is operated by push button control on the main control board, the pulverizer storage bin being equipped with high and low level alarm.

A further item of considerable economic importance is that with pulverized coal firing the scale formed on the billets has been decreased to less than 50 per cent of the amount formed on corresponding billets when the furnace was heated by oil and gas.

The success of this first pulverized coal installation at this particular plant resulted in a decision to apply pulverized coal firing to two other billet heating furnaces located in the same building, but some 200 feet or more away from the first furnace. Figure 9 shows the general arrangement of the furnaces with relation to each other, and also shows the means provided for feeding the raw coal to the second pulverizer located adjacent to the two additional furnaces to be fired. As is normally the situation in steel mills, the space available was at a premium and every precaution had to be taken to prevent infringement on space requirements for other purposes. With this in mind, the raw coal is being fed from the existing silo bin to the new pulverizer storage bin by means of an air conveyor system, the conveying line being 10 in. outside diameter, ¾ in. thick white iron cast pipe. In operation, air from a blower is delivered at about 4 psi, and the raw coal is fed from the silo by means of a belt feeder into the air stream, and carried in it to the storage bin over the pulverizer. Here the coal is separated from the air, and the air is passed through a small cyclone as shown to remove small particles of coal before being vented to the atmosphere. This system delivers coal at the rate of 25 tons per hour.

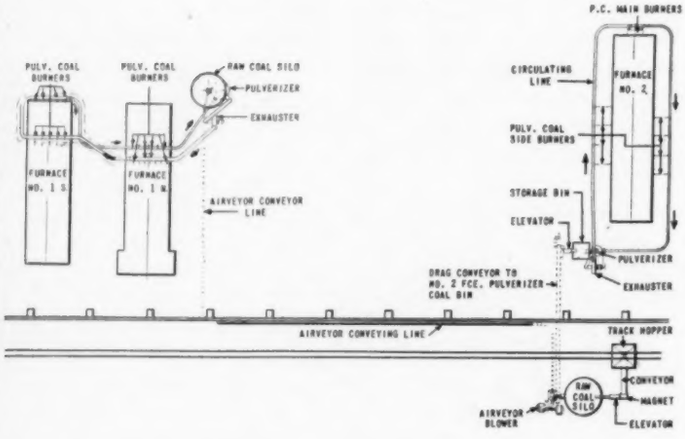
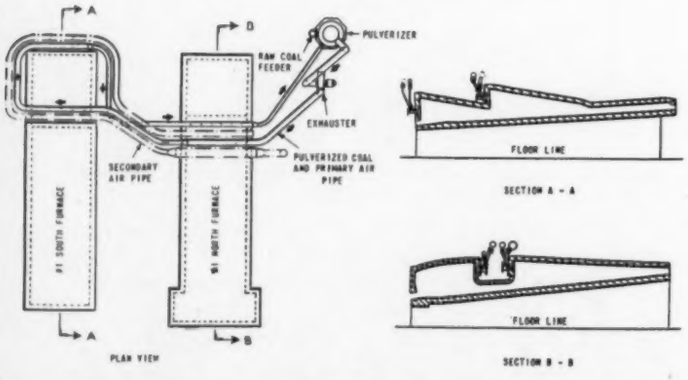


Figure 9 — Direct-fired circulating system for pulverized coal on billet heating furnaces.

▲

Figure 10 — Direct-fired circulating system on billet heating furnaces.



Direct fired circulating system firing forge furnaces — As a further example of multiple furnace operation on

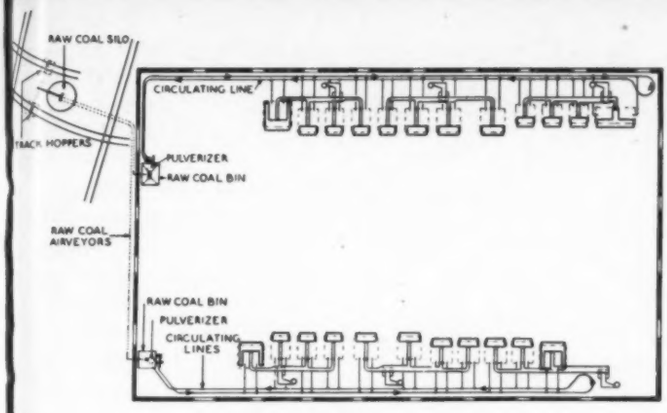


Figure 11 — Direct-fired circulating system for pulverized coal on forge furnaces.

a direct fired circulating system, Figure 11 shows an application to a number of forge furnaces. As shown, the forge shop contains two lines of furnaces, one along each side of building, there being 12 furnaces along one side and 11 along the other. Again, with space at a premium, every consideration had to be given to making the installation without interfering in any way with plant operations. It will be noted that the raw coal silo is fed through either one of two track hoppers, the two hoppers being installed so that there will be flexibility in the unloading of coal shipments, regardless of the normally busy conditions of the tracks. From the silo the raw coal is fed to the pulverizer storage bins by means of an air conveyor system similar to that previously described. There are two pulverizers, one feeding 11 furnaces along one side of the building, and the other feeding the 12 furnaces along the other side of the building, each pulverizer being capable of delivering 6000 lb of pulverized coal per hour at 95 per cent through 200 mesh, with coal having a grindability of 50. As these forge furnaces are operated under a slight positive pressure, duct work is shown for taking the combustion gases, with a certain percentage of coal ash that will be in suspension, through induced draft fans, and deliver it to the stacks.

CONCLUSIONS

In conclusion it can be stated as the result of experience that in the metallurgical industry there are many types and sizes of furnaces that can be satisfactorily fired with pulverized coal. In the iron and steel industry there are ingot, bloom and billet heating furnaces, annealing and normalizing furnaces, forge furnaces, and with the direct fired circulating system as described, multiples of small furnaces such as small forge and rivet heating furnaces, having individual coal consumption from a minimum of less than 50 lb per hour per furnace and up. In the non-ferrous industry there are copper, lead and zinc melting furnaces, zinc fuming furnaces, etc., to which no reference has been made specifically in this discussion. Some of these furnaces are melting furnaces in which the bath of molten metal is protected by a layer of slag; some are heating furnaces of a type on which slag on the surface of the material to be heated is not detrimental to the heating process; in either of these types of furnaces, normally operated at high temperatures, the ash from the coal can be handled satisfactorily in the molten state.

Other furnaces, regardless of the temperatures being employed, must necessarily be fired with coal having an ash that will be in the dry state. In certain heating processes the presence of sulphur might be deleterious to the product, whereas in others it might not be harmful. Regardless of what the specific requirements might be, however, and provided the limitations involved are thoroughly appreciated, a coal having a suitable ash fusing temperature, sulphur and ash content, and other characteristics desired can be selected for use in the large majority, if not all, instances. The judicious selection of coal to be used, and a high degree of fineness of the pulverized coal as fired together provide a satisfactory solution to any combustion, ash and sulphur problems present in any specific application of pulverized coal firing.

In the firing of larger furnaces it is frequently economical to use an independent coal pulverizer for each installation, thus utilizing the direct firing system. With smaller furnaces a number of them can be fired by one pulverizer, utilizing the direct fired circulating system and providing individual control for each of a number of burners. The decision as to the system to be installed is determined by such factors as the rate of coal consumption per unit, the number, size and location of the burners to be fired, frequency of heating cycle, physical limitations of the installation itself, and, finally, economic considerations.

DISCUSSION

PRESENTED BY

C. F. HERINGTON, Consulting Engineer, Pulverized Coal Division, Amsler-Morton Company, Pittsburgh, Pennsylvania

L. S. WILCOXSON, Executive Assistant, Babcock and Wilcox Company, New York, New York

D. F. SAWTELLE, Metallurgist, Malleable Iron Fittings Company, Branford, Connecticut

ROBERT I. GUMAER, Fuel Engineer, Jones and Laughlin Steel Corporation, Aliquippa, Pennsylvania

P. F. KINYOUN, Combustion Engineer, Bethlehem Steel Company, Lackawanna, New York

J. L. MILLER, Combustion Engineer, Republic Steel Corporation, Cleveland, Ohio

RICHARD B. ENGDAHL, Research Engineer, Battelle Memorial Institute, Columbus, Ohio

C. F. Herington: I agree with Mr. Wilcoxson that there is a field for circulating systems. Twenty-five years ago we were putting them in Pittsburgh and there are some in operation today that were installed in 1917, and they are operating very successfully; they

supplied very small furnaces and others which were larger.

But there are several points that I would like to add to Mr. Wilcoxson's remarks, and that is on slide No. 6, he brings back a return line, and he distributes that line to three different points, and I would just like to know what that means.

L. S. Wilcoxson: Actually, the return line from the circulating system is split; one portion of the return entering the bottom of the pulverizer and passing through the pulverizer itself, and the balance bypassing the pulverizer and entering at the exhauster suction.

The system is operated so that the control valve in the section of the return line that goes to the pulverizer is automatically regulated to insure a constant quantity of return, which is at essentially constant density. With this regulated constant quantity of return always going through the pulverizer, the balance of the return is readmitted to the circulating system through the fan inlet.

Having a constant quantity of coal and air from the return passing through the pulverizer at all times, it is possible to regulate the quantity of new coal added to the system in proportion to the new air that is being added, and thus maintain essentially constant density of the coal and air being discharged from the pulverizer and maintained in the circulating system.

The arrangement of circulating system such as illustrated in Figure 4 is such as to insure the least pressure drop throughout the system, and therefore the minimum head necessary on the fan. Naturally, there is no object in employing too high a static pressure on the fan as it is merely waste of power, but an essential requirement of any circulating system is that there should be sufficient static pressure in the cirulating line at the point where the last burner is taken off to insure satisfactory operation and performance of that burner. If the static pressure gets too low at the last burner, then there is liable to be trouble due to improper combustion conditions.

In the arrangement as shown in Figure 4 it will be noted that the last burner in the circulating system is that in furnace No. 12, and there is necessarily a drop in pressure due to friction through the line beyond that burner in returning to the pulverizer, so that actually two objects are accomplished by this one requirement. There is necessarily a pressure drop through the line beyond the last burner, and the necessary pressure to overcome this is normally amply provided for in assuming a static pressure at the last burner that is adequate for furnace operation.

D. F. Sawtelle: Some of the illustrations used in Mr. Wilcoxson's paper, illustrating the conversion to a direct fired circulating system of malleable iron annealing furnaces, were very familiar to me as they illustrated the installation at our plant. I have no questions on this and can only say that its successful operation over a period of the last six months speaks for itself.

In the use of pulverized coal for melting malleable iron the fineness of the coal becomes important to the metallurgist, as the carbon content of the bath of molten metal must be regulated by the type of combustion and the fineness of the coal, both being dependent on the other.

Would Mr. Wilcoxson care to make a few remarks on fineness control?

L. S. Wilcoxson: On the question of fineness control, I believe very sincerely, as I said in the paper, that the fineness of pulverized coal is of utmost importance, regardless of what the particular application of the pulverized coal might be.

As far as regulation of fineness in any particular operating system, that can be accomplished provided, of course, the pulverizer as installed is of sufficient capacity to give the capacity required at the particular fineness considered necessary for operation.

In other words, if one has a pulverizer which has a certain capacity in terms of a specified number of pounds of coal per hour at a certain fineness when using a certain grindability of coal, and that capacity is just what is required in the furnace for operation, it is going to be difficult to get an increased fineness.

If, however, the pulverizer has an additional capacity over that which is actually needed in the furnace, then that additional capacity can be translated into fineness of product, and higher fineness can be obtained for the operation of the furnace.

R. I. Gumaer: Mr. Wilcoxson didn't mention producer gas and it would seem to me that powdered coal may show attractive savings over the average producer gas plant. Our experience in pulverized coal firing of boilers indicates that the cost per million Btu is somewhere around half the cost of producer gas, that is, producer gas applied to metallurgical furnaces.

The question that I think bothers most of us is how we can cope with this slagging trouble. Coal with .6 per cent sulphur and 6.0 per cent ash, 2500-2700 F ash fusion temperature, are not always available.

What is the general effect on ordinary firebrick refractories, such as would be used in a billet re-heating furnace, if the coal does fuse slightly? It is possible that there are some pusher-type billet furnaces where a certain amount of slag on the steel would not be objectionable, and if an attempt were made to use a low-fusing coal in such a furnace, would we look for trouble with the brick work?

Also, how does pulverized coal firing lend itself to automatic combustion control — that is, fuel-air ratio control?

L. S. Wilcoxson: On the first point mentioned, namely the economics of pulverized coal firing as against producer gas firing, the figures given are very interesting, and I believe they can be confirmed in many installations. Furthermore, where a new installation is being considered, the initial capital expenditure involved for pulverized coal equipment is considerably less than for gas producer equipment for equivalent Btu production.

As to the effect on refractories with pulverized coal firing, where the ash in the coal has a high fusing temperature so that one is dealing with dry ash, there are no deleterious effects on the lining of the furnace. Stalactites of dry ash may form on the roof brick work, which build up and ultimately drop off, but the brick work itself isn't in any way affected.

If, on the other hand, coal having a very low ash fusing temperature were employed, so that the ash was in a molten condition in the furnace, there would naturally be high brickwork maintenance.

I think I have emphasized the fact that pulverized coal, per se, cannot be considered as a cure-all for everything that might come up in connection with fuel utilization. There are cases where it definitely is applicable, and others where it is definitely not applicable, and it will not answer every condition. The applicability of pulverized coal firing to metallurgical furnaces is largely dependent upon the operating temperatures required in the furnace, and the selection of a coal having an ash fusion temperature that will result in the ash being in the right condition — whether this be dry or molten — during the operation of the furnace.

The pulverized coal circulating system is as equally susceptible to automatic control as gas or oil firing. With the pulverized coal circulating system there is maintained a constant density of the pulverized coal and air in the system. The closest analogy one can give is normal gas firing operation, as with the pulverized coal circulating system the burners can be turned on or off and adjusted with essentially equal facility to normal gas burner operation.

In the Beaver Falls installation mentioned in the article, there is semi-automatic control installed at the present time, the actuating mechanism being through a selector valve on the control panel. The second installation at this same plant, also illustrated, will have completely automatic temperature control from radiation pyrometers that are installed in the furnace actuating burner control valve positions.

P. F. Kinyoun: How do you measure the coal to get fuel impulse for use with automatic combustion control? When using gas an orifice plate is used.

L. S. Wilcoxson: As the temperature impulse modifies the burner valve position, increasing or decreasing the quantity of coal and air to the burner, the demand for total air in the system will be increased or decreased accordingly. This air, which is admitted through the pulverizer, will vary the differential across the pulverizer, and this differential actuates, through the feeder controller on the pulverizer, the coal feed to the pulverizer, so that the relationship of new coal to new air to the pulverizer, and hence to the system, is maintained essentially constant, and thus also maintains essentially constant density of coal and air in the circulating system.

This illustrates further the analogy to gas firing. With gas there is an essentially constant Btu per unit of volume of fuel, while in this pulverized coal circulating system there is maintained constant density of coal and air, and thus essentially a constant Btu per unit of volume.

As to burner regulation, this can be tied in, as we have done with the Beaver Falls installations, with the primary coal and air and also with the secondary air. This can be made completely automatic.

J. L. Miller: Modern application of powdered coal firing to metallurgical furnaces in the steel industry is of much interest to me due to experiences over the past fifteen to twenty years. I was rather in hopes that we would find out something new but I am still of the opinion that, except for very limited application, it is not a desirable fuel for reheating steel ahead of a rolling operation. Serious trouble confronts the fuel engineer should he have to change over from either liquid or gas fuel to powdered fuel in any reheating operation where surface and finish are of importance. Round billets or tube blanks being heated in the subject installation of Mr. Wilcoxson's paper are, in my opinion, the main answer to reasonably satisfactory operation.

My experience on powdered coal firing has covered sheet mill furnaces and the production of deep drawing auto body sheets — loose rolled after charcoal dipping. Here a very close control of fuel quality and analysis was most essential to avoid excess open surface and the resultant expensive re-treatment or sale as seconds. True, the charcoal dip was also a factor, but very close control of the quality of the charcoal, the preparing, fermenting and aging of this mixture could never be neglected, no matter what the fuel used for heating.

In a large bar mill plant in the Youngstown district a complete central system was installed for powdered coal firing of the mill's furnaces. This installation has not been in use for over ten years and was replaced, certainly not on the basis of fuel heating cost, but on the more important factors of roll maintenance, satisfactory product and yield. Another bar mill in the Pittsburgh district using powdered coal for slab heating for rolling tie plate was changed over to natural gas firing and has, in its two years operation since the change, well justified itself. I again assure you that this job was not justified on a fuel cost saving.

The cost of installation comparison between oil and powdered coal, as set up before us in Mr. Wilcoxson's paper, does not jibe with costs with which I have been dealing on oil installations in some of our own plants recently. I would want to check these rather carefully, however, before making any further comments as to relative installation costs.

L. S. Wilcoxson: One point Mr. Miller brought out has, I think, confirmed exactly what I said, or tried to say, in the paper, namely, that pulverized coal cannot be considered to be the answer to all problems in all metallurgical furnaces. I thought I had made that clear, but if I didn't, then I am very glad Mr. Miller brought it out, because it should be made clear.

But despite the fact that there are some metallurgical furnaces where surface finish and other requirements are such that pulverized coal is not the fuel to use, there are many other furnaces where pulverized coal can be used, and used effectively and economically, for the fuel. There is no question regarding this point.

As to the economic figures to which Mr. Miller referred somewhat disparagingly, all I can say is that they were predicated, not upon wishful thinking, but partly upon actual installations made and partly upon investigations of plant conditions where other installations were contemplated.

R. B. Engdahl: I had an opportunity during the last two years to wade through nearly everything that has been written about pulverized coal for metallurgical furnaces, and I think Mr. Wilcoxson's paper goes more to the heart of the practical problems and the costs and the ways that you can use pulverized coal than anything that has ever been given. He emphasizes two things which, from my experience in pulverized coal, indicate that formerly the equipment was just not available to meet the problems that came up.

One thing he emphasized is fineness. It is not only through a recent realization of fineness that we have

(*Please turn to page 88*)

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"In November, 1943, we installed BUSS Super-Lag fuses in the switch and since that time we haven't had a single shutdown on that important circuit."

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Drill Department. Another spot where a useless shutdown can be very costly in lost production, wasted man-hours, and needless overall expense.

Here is another outstanding example that demonstrates how Buss Super-Lag fuses are helping to keep production running smoothly, how they reduce lost man-hours, and save trouble and grief for electricians and maintenance men.

If you have a problem similar to the one at Doyle Machine and Tool Corporation, doesn't this example indicate how you can profit by the use of Buss Super-Lag fuses?

Buss fuses require no maintenance or periodic inspection. They don't open needlessly. If one opens, you can be sure some condition needs correction. When one opens, it requires less than 45 seconds to renew with an inexpensive link.

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The fuse case is designed to insure good contact on the link, even when the fuse is renewed by an inexperienced person—and it is so designed that vibration or heavy overloads or the constant heating and cooling of the fuse will not permit poor contact to develop. Thus excessive heating, which causes fuses to blow needlessly, is prevented.

The fuse link used is the famous "BUSS Super-Lag." It has lag-plates attached to it. These give it a long time-lag so that unusually heavy starting current or other harmless overloads will not cause the fuse to blow.

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Pass the word along that all purchase records dealing with circuit protective devices should be immediately changed to call for BUSS Super-Lag Renewable fuses. Then, as fuses are replaced or new installations made, your plant will automatically get the benefit of the carefree, trouble-proof protection that BUSS Super-Lag fuses afford.

BUSSMANN MFG. CO., St. Louis 7, Mo.
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FUSES Sold Through Wholesalers

Wilcoxson DISCUSSION

(*Continued from page 85*)

come to the point where some furnaces that had previously failed because of poor fineness can now be fired successfully. It is also because now we know how to pulverize more finely. Equipment has advanced in pulverizing just as in everything else.

Possibly some of you, like Mr. Miller, have had some sad experiences because you have had poor pulverizing in the past. You might review some of those experiences and see what modern equipment will do.

The other thing which was emphasized was the direct fired circulating system. The circulating system is not new, but the direct fired system is. It solves a lot of space and flexibility problems. In our work at Battelle Memorial Institute for Bituminous Coal Research, Inc., we have fired a small forge furnace similar to the one Mr. Herrington mentioned, each burner firing down to eighteen pounds an hour; and when you get a lot of such furnaces of different sizes, you will see that flexibility is of paramount importance.

Such systems in the past have been inadequate because of the lack of two things, flexibility and fineness. Fineness solves all sorts of problems, on ash, on transportation, and in combustion.

As for clean work, you all know the importance of the radiant tube furnaces today in the handling of clean work in various annealing processes, steel and nonferrous as well. We are now getting clean results in a pulverized coal fired radiant tube furnace. The ash blows right out of the tube and we get better temperature distribution than with any other fuel. I think there are many more furnaces where direct fired pulverized coal can be used with success.

Shaad DISCUSSION

(*Continued from page 73*)

better efficiency and ease of operation. There is no real reason why non-conducting crucibles or liners cannot be used. I would make a rough guess that about 10 per cent more capacitors would be required for the non-conducting crucible to maintain the generator power factor at unity.

Walter Giele: I have had some years of experience in the melting of metals by means of induction heating but none with other applications of induction heating.

I am curious to know whether the application of induction heating, on operations other than melting, has peculiar advantages with respect to the elimination of the formation of oxides on the surface of the work.

G. E. Shaad: That is primarily a question of time. One of the biggest advantages in the use of induction heating for shell forging is the elimination of scale, for in the four minute heating cycle on a 3 inch bar practically no scale is formed. If, however, the heating time is lengthened considerably, scale will be formed unless a controlled atmosphere is used.

F. T. Chesnut: One of the intangible savings that showed up when induction heating began to be used for forging operations was that the dies, used to form the steel, had a very considerably longer life than when used on blanks heated by other methods. By rapid induction heating, only a thin soft scale is formed that acts more as a lubricant on the dies than as a wear element.

H. L. Watson, Jr.: I would like to ask Mr. Shaad two questions: First, what method of temperature control is employed on most of the induction heating equipment used for heating for forging and for heating other than melting, or is it entirely controlled by time cycles? Secondly, I understand that some induction heating has been done on inside diameters. I wonder if Mr. Shaad has any comments to make on that process?

G. E. Shaad: In the majority of present day installations, the temperature control has been purely a time control, but there is no reason why other automatic controls cannot be used.

In the induction heating of electrolytic tin plate, the operation is being controlled by photo-electric tubes, and I know of at least one experimental unit where power will be controlled by a radiation thermocouple.

There has been considerable work done on internal hardening, with excellent results. The best known installations are those for hardening the inside of cylinder liners for diesel engines and the hardening of wheel hubs for the automotive industry.

C. C. Levy: One or two things have occurred to me as being extremely interesting in Mr. Shaad's paper. One is the mention of base frequency. It is not quite clear to me as to just what base frequency means. I would like to have an idea from Mr. Shaad as to how base frequency is determined, and also whether any great difference from base frequency is to be considered as correct for induction heating problems.

The other comment is in regard to transmission. As Mr. Shaad mentioned, machines are being paralleled now in order to get larger capacity buses — a heavier and stiffer bus — to supply larger induction heating loads. Concentric cable is available and of course we know it is all right, but we do not know all about what happens when we have troubles on the line. And the particular problem that is going to be difficult to solve is how you are going to protect your circuits when you parallel several machines and have to increase the interrupting capacity of contactors which are not very satisfactory at the present time. That is a problem which definitely has to be solved before we can go on connecting these machines in parallel and expect them to handle loads under those conditions.

G. E. Shaad: If you will take a particular size of bar and calculate, for the different frequencies, the electrical efficiency of the circuit, the efficiency will increase with frequency until you reach a point at which the curve levels off and efficiency remains practically constant. The frequency at which the efficiency levels off is what we call the base frequency.

The use of higher frequencies, within limits as Mr. Chesnut pointed out, has little effect upon the efficiency, while lower frequencies can be used, at the expense of efficiency, down to the point where sufficient power can no longer be coupled into the work.

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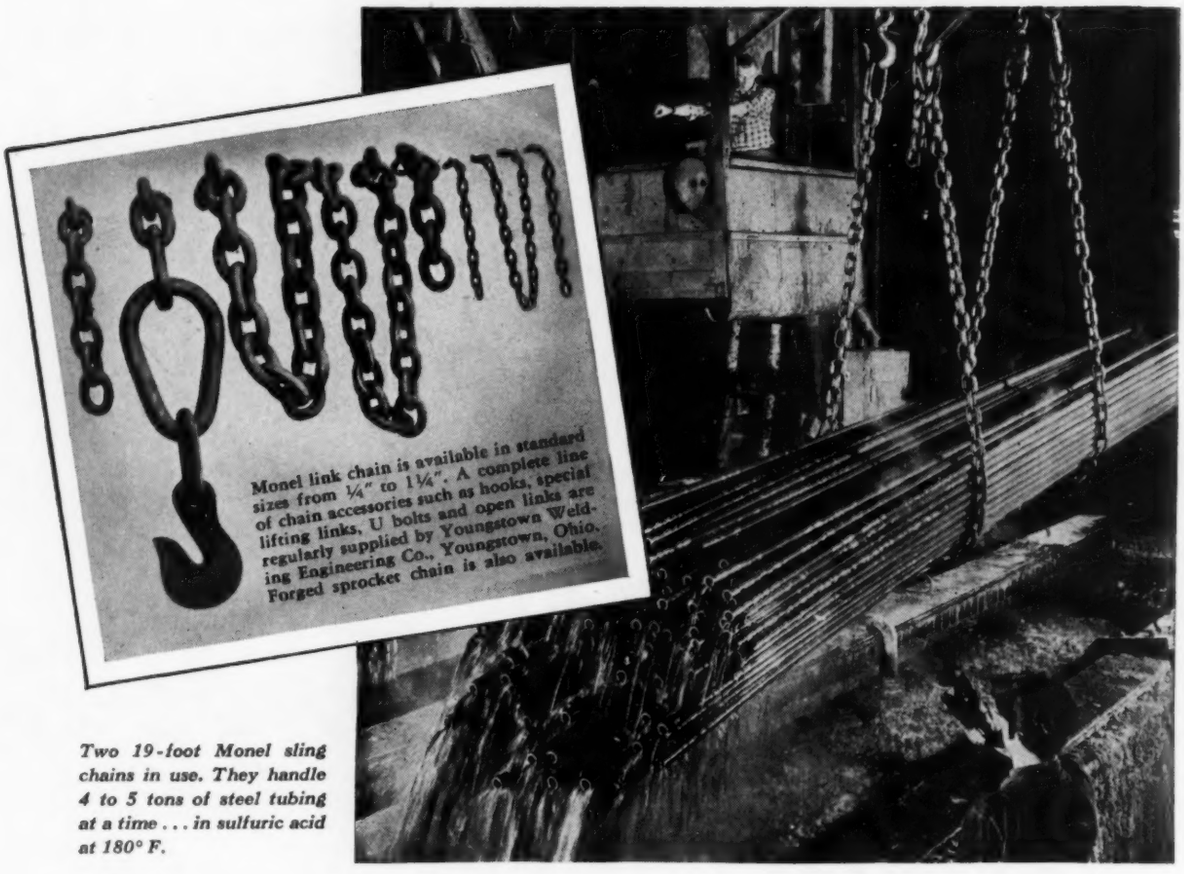
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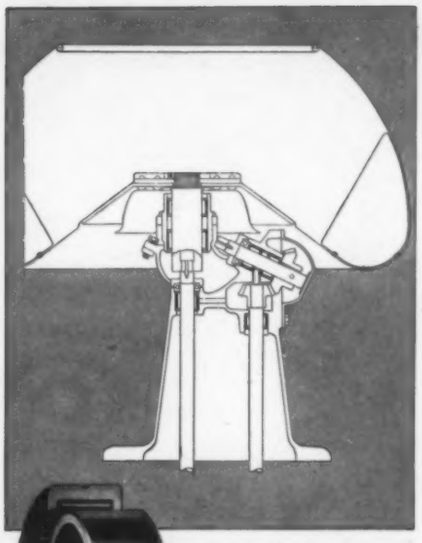
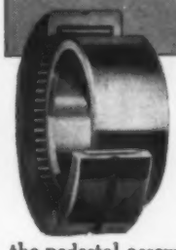
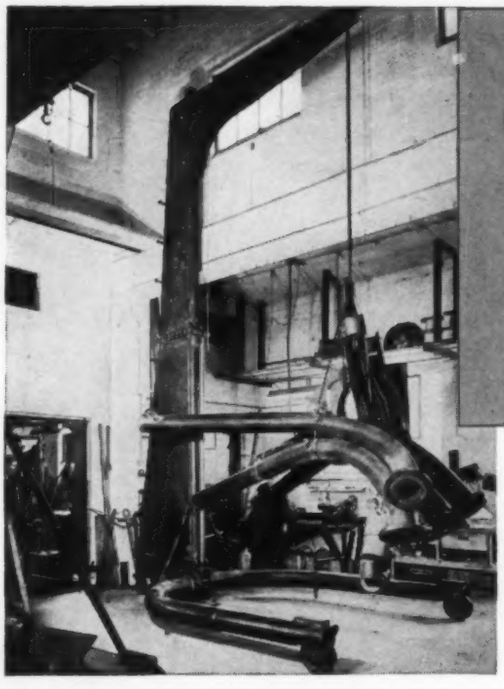
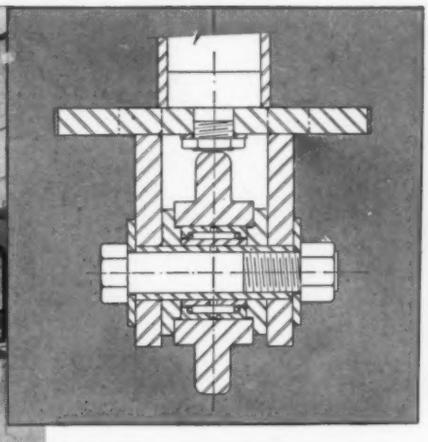


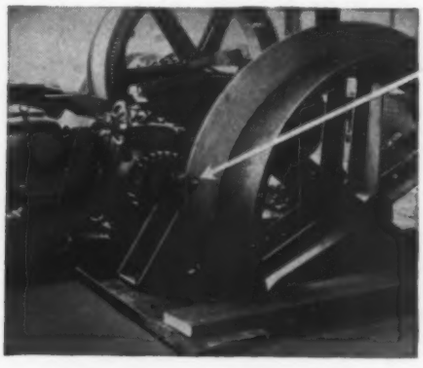


THE DRY CLEANING BUSINESS is at an all-time peak and equipment is being subjected to severe performance tests. Cross-section shows the application of Torrington NCS Needle Bearings in the pedestal assembly of a dry cleaning unit manufactured by Columbia Appliance Corporation. Now operating almost continuously day after day, these compact anti-friction bearings are demonstrating the advantages of their high capacity and long service life under heavy load conditions.





THIS PORTABLE HYDRAULIC HOIST, manufactured by Federal Aircraft Works primarily for aircraft engines, handles other heavy parts with equal facility. Cross-section shows installation of Torrington Type NCS Needle Bearing in the hydraulic ram sprocket, where it is subject to extremely heavy loads. Its low coefficient of friction is an important factor in contributing to smooth, anti-friction operation.



CAM FOLLOWERS have proven to be an interesting application of Torrington Type RC Needle Bearings in the wire manufacturing machinery of New England Butt Company. They are used to impart a "wobble" motion to the loose fitting ring on the drum of the capstan, the ring guiding the wire so that it "lays" correctly on the drum which revolves at a maximum speed of 125 feet per minute. The high capacity and elimination of stress concentrations of these heavy duty Type RC Torrington Needle Bearings make them ideal for this purpose.

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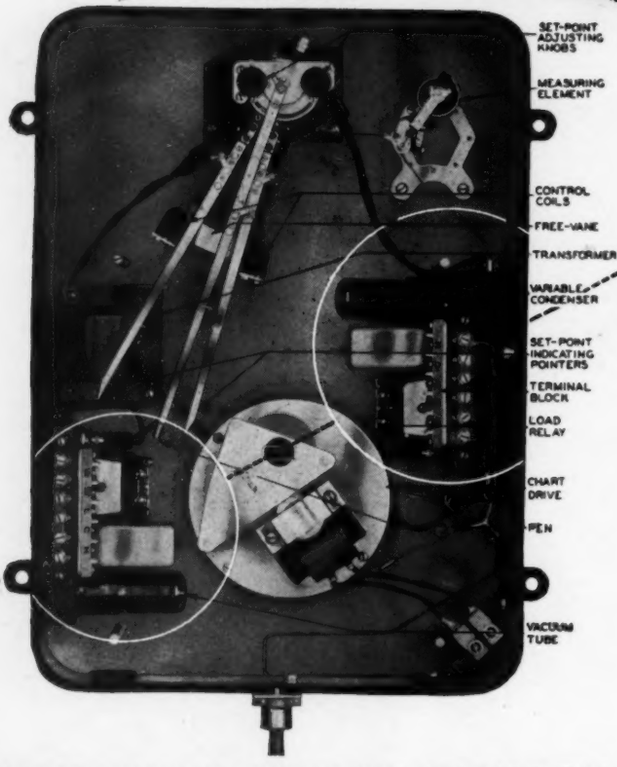

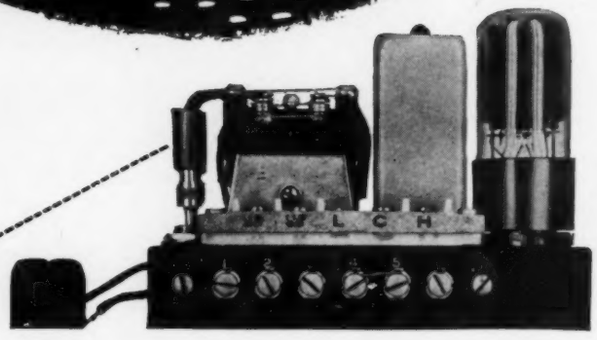

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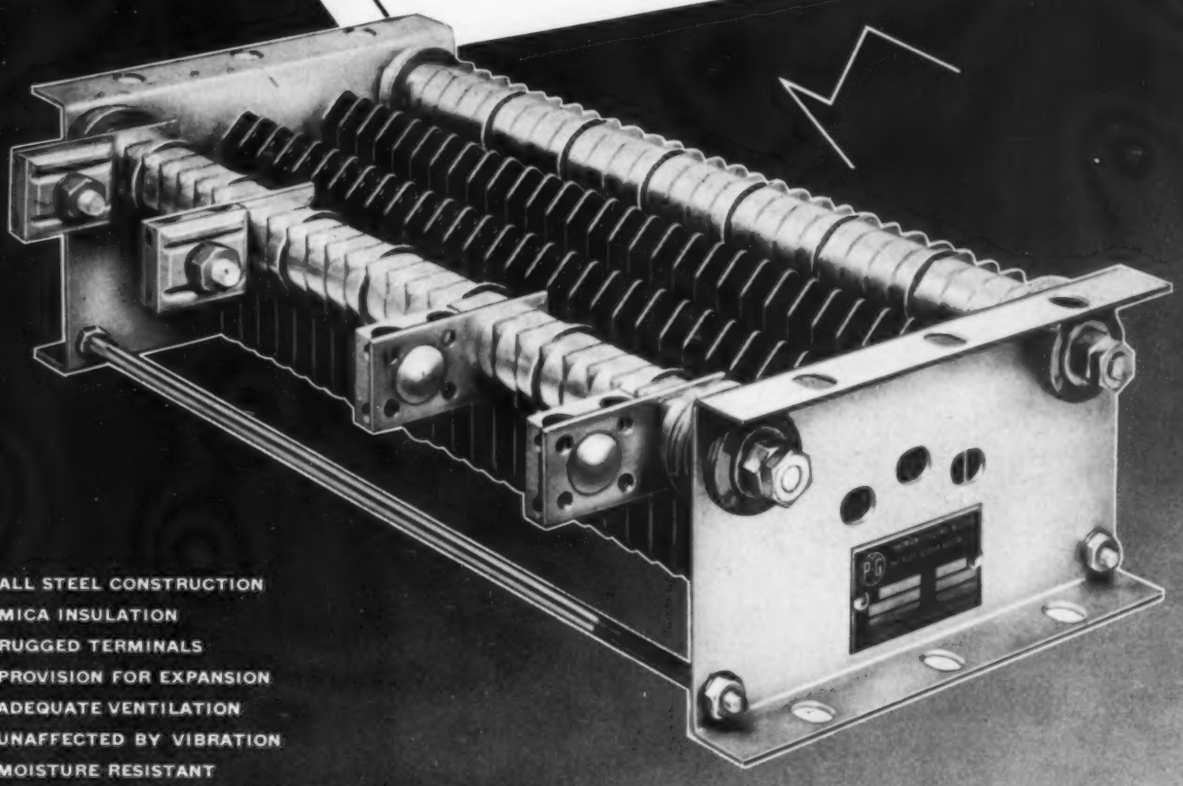

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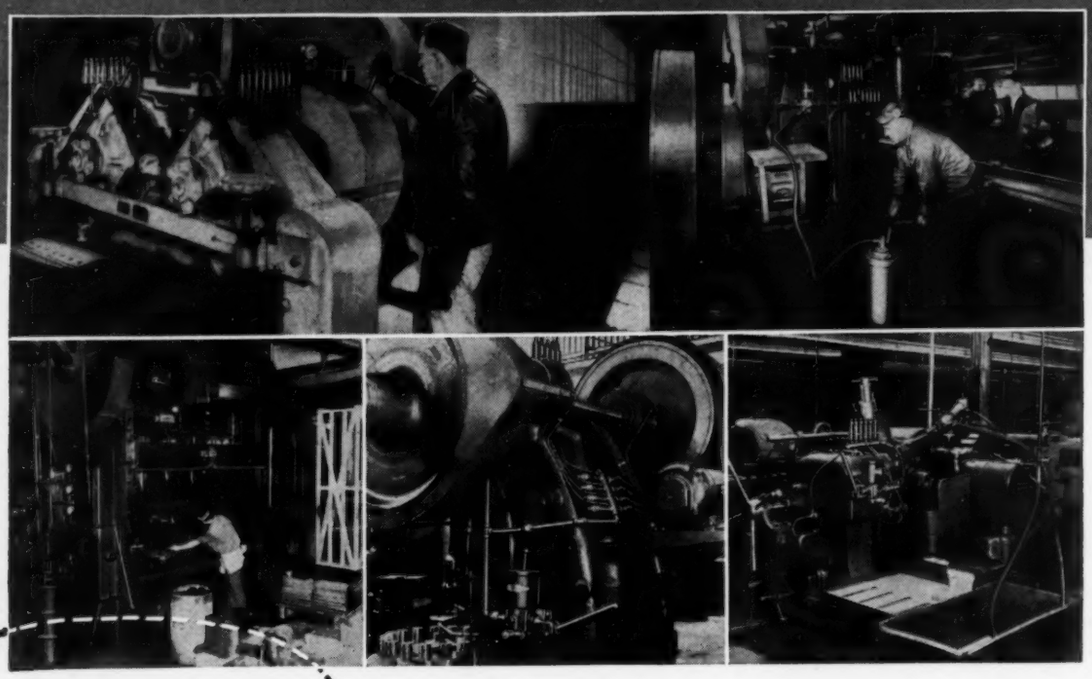
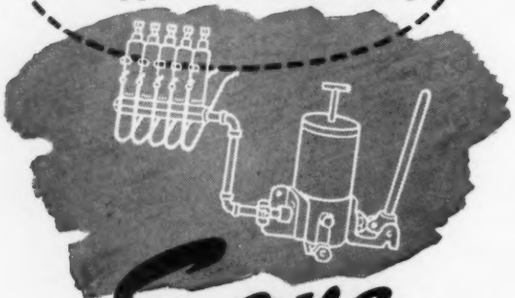


THE *Modern* WAY TO LUBRICATE all types of machinery



Save

MAN HOURS
MACHINE HOURS
BEARINGS
POWER
and reduce accidents

★ ★ ***BACK THE ATTACK— BUY MORE WAR BONDS*** ★ ★

I44-7C

The Lincoln *modern method* of centralized lubrication, makes it possible for all bearings on one machine, or on a series of machines, to be lubricated from a central source without stopping the machines.

The Lincoln Centro-Matic System consists of a number of Centro-Matic Injectors—one for each bearing—and a hand-operated, or a power-operated Centro-Matic Lubricant Pump. The system is easy to install and will help increase your plant efficiency, not only today, but for years to come.

☆ *Special Engineering Service*

Lincoln Engineering Company maintains a staff of specialized engineers who are prepared to assist you in solving your industrial lubrication problems without obligation to you. We invite you to avail yourself of this service.

Write for **Descriptive Literature Today**

ARMY E NAVY

LINCOLN ENGINEERING COMPANY

Pioneer Builders of Engineered Lubricating Equipment

5701 NATURAL BRIDGE AVE., ST. LOUIS 20, MO., U. S. A.

LINCOLN

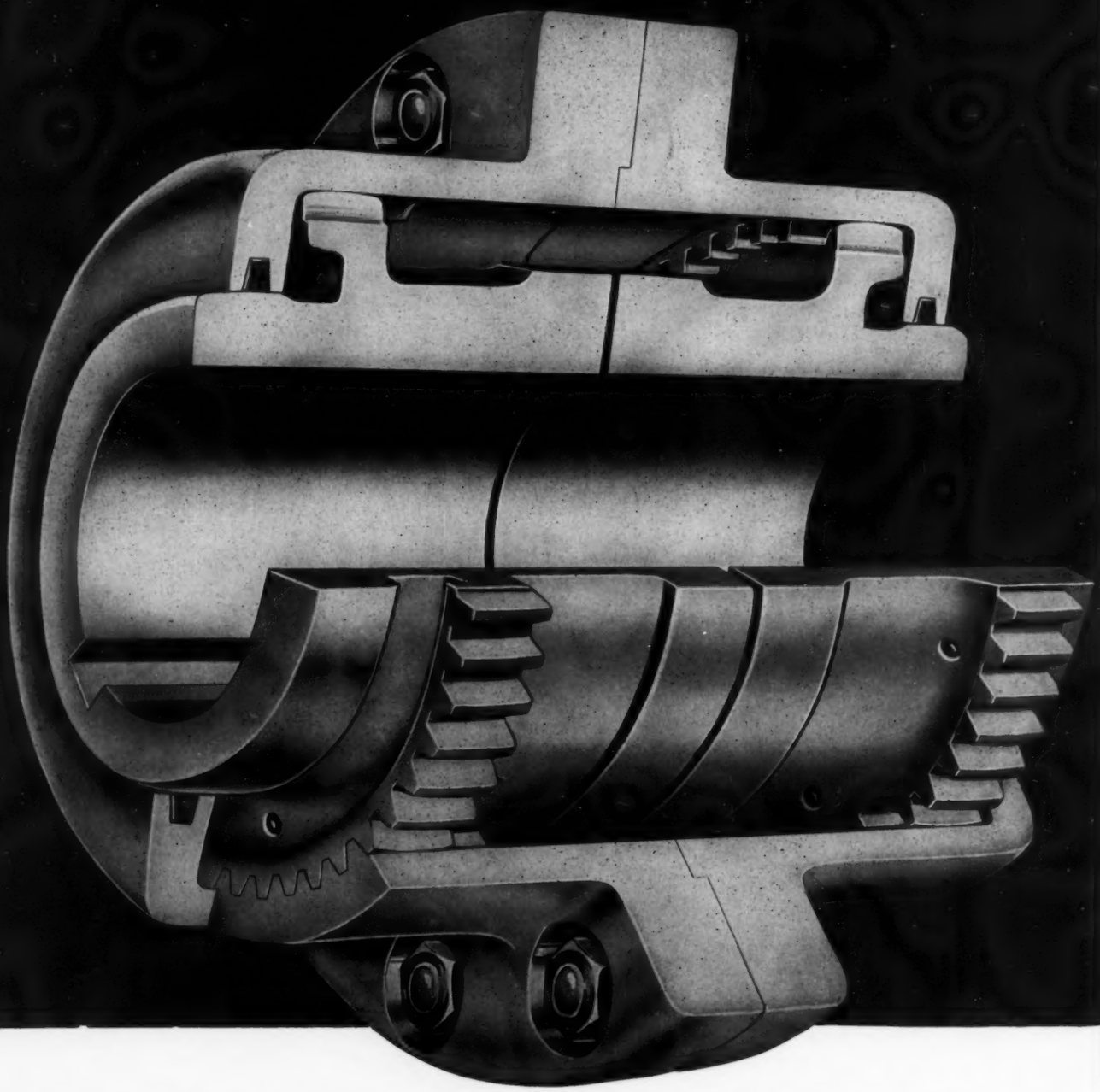
Want a marketing edge?

Here is a vertical precision mill that rolls hot rounds within cold round tolerances. It's the kind of equipment that gives you an important sales edge in tomorrow's business battle. It's another example of the progressive M-H attitude toward customer's production problems. Mackintosh-Hemphill in their particular sphere of metallurgy, engineering and manufacturing have led the world for 140 years in *advanced industrial thinking*. They offer you a cooperative service that is constantly helping others to find new ways to greater sales and profits through the installation of better heavy duty equipment.

MACKINTOSH-HEMPHILL CO., Pittsburgh & Midland, Penna. · Makers of the rolls with the red wabblers

OTHER PRODUCTS:—*Rolling Machinery . . . Shape Straighteners . . . Strip Coilers . . . Shears . . . Levellers . . . Pinions . . . Special Equipment . . . Iron Steel Castings . . . The NEW Abramsen Straightener . . . Improved Johnston Patented Corrugated Cinder Pots and Supports ... Heavy Duty Engine Lathes.*

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST

FLEXIBLE COUPLINGS

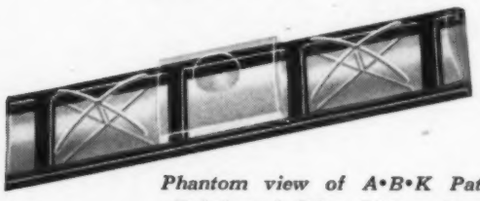
POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

A·B·K
Laminated Plastic Bearings
improve production records

A·B·K Roll Neck Bearing with separate collar.

A·B·K Patented Reinforced Edge Slipper Bearing, made in required sizes to blueprints.



Phantom view of A·B·K Patented Reinforced Edge Slipper Bearing.

Industrial and Marine Uses
A·B·K Laminated Plastics

- Steel Mills
- Textile Mills
- Rubber Mills
- Paper Mills
- Industrial Truck Wheels
- Marine Stern Tube Bearings
- Pintle Bearings
- Rudder Bearings
- Pump Valve Discs
- Safety Tile and Tread

WITH production stepped up to new peaks, with heavy duty equipment rolling for longer periods without shutdown, A·B·K plastic bearings have proven superior to other type bearings.

In addition, A·B·K plastic bearings have established new records in many industrial plants for . . .

Lowering power consumption.
Lengthening bearing life.
Non-scoring of Roll Necks.
Eliminating lost time due to shutdown for bearing replacement.

A·B·K plastic bearings developed by American Brakeblok research engineers are made to tested formulae to fit the particular job for which they are intended.

The research and engineering facilities of A·B·K, designers of these improved laminated plastics, are available without charge for help in solving *your* bearing problems. Write American Brakeblok Division of American Brake Shoe Company, 4600 Merritt Avenue, Detroit 9, Michigan.

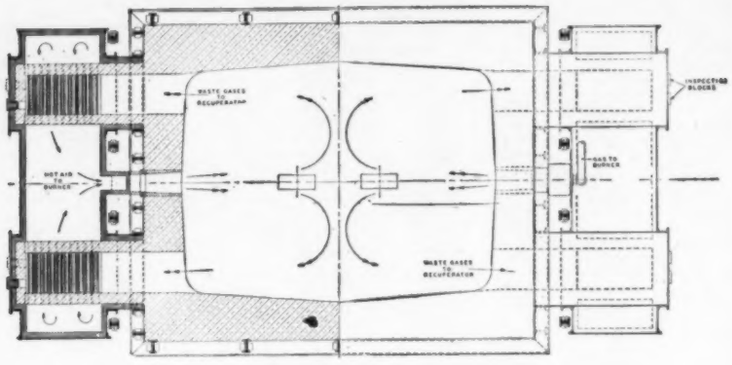
American Brakeblok
TRADE MARK REG. U.S. PAT. OFF.

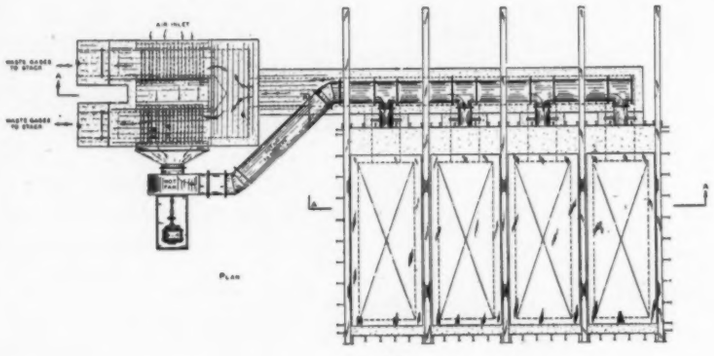
DIVISION OF AMERICAN Brake Shoe COMPANY

"FITCH" RECUPERATORS for SOAKING PITS

⟶ OVER 170 PITS ⟵

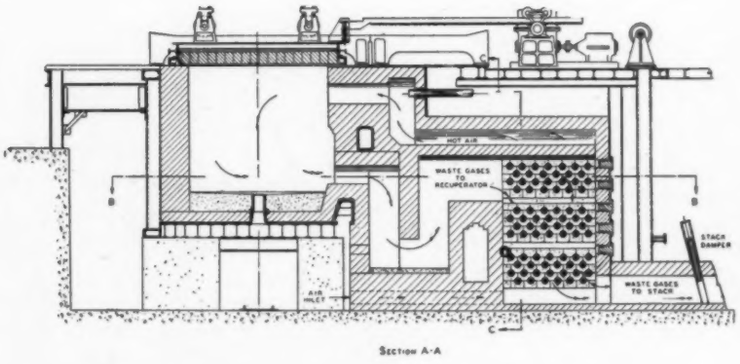
A Single Hole Equipped with Four Recuperators





A Single Recuperator Serving Four Holes

A Single Hole Equipped with One Recuperator



Section A-A

WE DO NOT BUILD FURNACES

Write for Bulletin No. 12

"FITCH" RECUPERATORS for the STEEL INDUSTRY

FITCH RECUPERATOR COMPANY

PLAINFIELD NATIONAL BANK BLDG. PLAINFIELD, NEW JERSEY

NEWS SUPPLEMENT June 1944

Equipment
Personnel
Literature

Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

WEIRTON CONTINUES TO SET NEW RECORDS

▲ New all-time production records were established in May in the strip mill and the tin mill of the Weirton Steel Company. The new records include a total production of 129,374 tons of hot rolled flat rolled steel and 94,037 tons of cold rolled flat rolled steel. This record-breaking production was the result of the combined efforts of a number of different departments.

Weirton Steel Company's hot and cold flat rolled production is finished into a wide range of products, all of which are manufactured under War Production Board directives.

In addition to the above record, new all-time high marks were set in the 10 in. hot mill, in the strip pickling department and in the cleaning, annealing, skin rolling, cutting, and finishing departments of the tin mill.

The Weirton Production for Victory Committee pointed out that May is the fourth consecutive record-breaking month and that the new records add to the long list that started immediately after Pearl Harbor and has been growing steadily ever since. Weirton's production record has been made possible, it was stated, by the fact that not a single minute of production time has been lost in any of the Weirton mills since long before Pearl Harbor.

SWITCHGEAR FEATURES SELF-CONTAINED PANELS

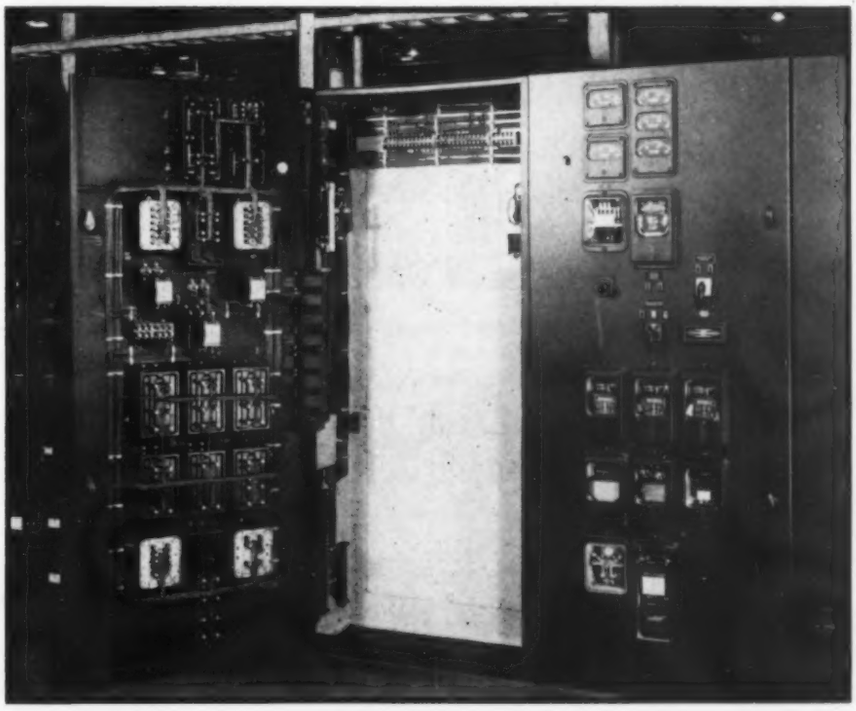
▲ War demands for steel have made necessary a number of increases in mill capacity, not only for sheet, plate and shape rolling, but also for blast and open hearth furnaces.

Most of these increases have been made in expansion of existing plants, but a few have been entirely new from the coke plant to the final steel finishing. In some mills hardly any improvements in equipment had been made in the past 30 years. However, in all recent installations, the most modern equipment, both mechanical and electrical, has been installed.

Typical of this expansion and modernization of electrical equipment is the metal-clad switchgear shown in the pictures with self-contained panels which carry instruments, relays, and control equipment. All panel mounted devices are flush type, and the relays are the new "Flexitest" or detachable design with self-contained test switches which combine to give devices which are simple, accessible, and at the same time occupy the minimum of space. The test switch blades also serve as the disconnecting means which permit quick removal of the chassis carrying the relay element and enables the maximum accessibility to all parts.

"Flexitest" relays simplify wiring at the rear of the panel since connections between the test devices and the relay are completely internal. This is read-

View of the Westinghouse heavy duty unitized metal clad switchgear panel, showing one of the panels open. Note the simplicity of the wiring.



ily apparent in the accompanying illustration.

The combination of the instrument and control panels with the switchgear and breaker structure is almost universal practice in steel mills, except for the main switchgear in generating stations. This results in a reduction in space, installation time and cost, and improvement in operating efficiency and convenience. The complete equipment is factory assembled and tested, so that it may be put into operation with the minimum of field testing.

RECTANGULAR MAGNET WIRE NOW AVAILABLE IN VERY SMALL SIZES

▲ Formex ribbon-rectangular magnet wire available in shapes as thin as 0.004 in., has been announced by the General Electric Company. The new Formex, being made for the war program, is one-fourth the size heretofore considered the low limit for thickness of this wire.

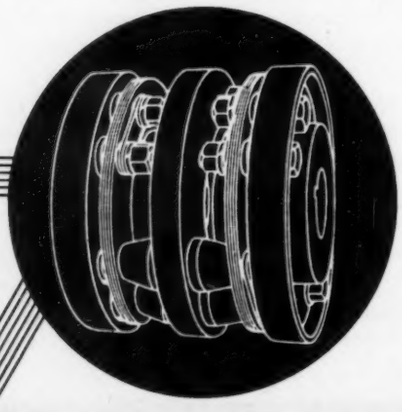
Smooth, strong, flexible, and able to withstand high-speed winding without damage to insulation, the new Formex ribbon-rectangular wire offers many application possibilities to producers of electronic devices and other electric components.

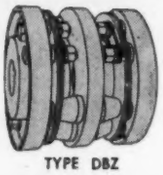
In coil winding, varnish treatment, assembly and actual operation, this new, ribbon-rectangular magnet wire, like Formex in all other shapes, presents many advantages. Its final dielectric strength, judged by its reaction to abrasion and winding, and the wire's resistance to abrasion, heat-shock, and solvents, is greater than that of other enameled wire. Moreover, tests to determine heat aging, flexibility and thermoplastic flow have proven the superiority of Formex over conventional enameled wire.

Because of its thinness, Formex ribbon-rectangular wire can be applied where round wire previously had to be used. In addition, this new magnet wire will substantially increase the winding space factor and may be used in place of larger-size, rectangular magnet wire to increase magnetic effect or reduce coil size.

THOMAS

Flexible COUPLINGS





TYPE DBZ

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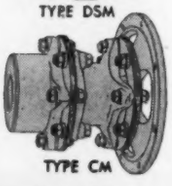

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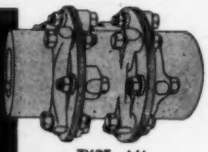


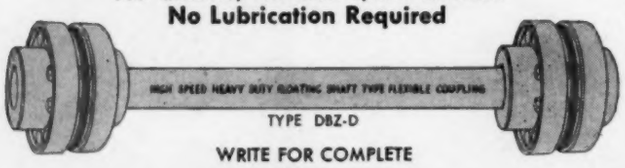
TYPE AM

TYPE-MT

Eliminate BACKLASH, FRICTION, WEAR AND CROSS-PULL

the four destructive evils of other types and makes of couplings that prevent a permanent care-free installation.

The Thomas All-Metal Coupling has:
No Chains, No Gears, No Rubber.
No Lubrication Required



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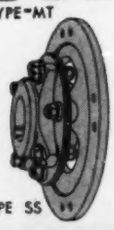


TYPE SS

WRITE FOR COMPLETE ENGINEERING CATALOG

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

ETCHER FOR MARKING TOOLS

▲ Anything made of iron, steel or its alloys can be easily and quickly etched with the new "Tool Room" Metal Etcher announced by the Ideal Commutator Dresser Company, 1045 Park Avenue, Sycamore, Illinois.

It is especially suitable for marking tools, gauges, reamers, dies, punches, jigs, fixtures, etc. Marks numbers, sizes and other important information. The mark is burned right into the surface so that it cannot be worn off through ordinary usage.

Depth of mark is controlled by etching heat and speed of writing. Four etching heats are 120, 240, 420 and 700 watts. Outstanding features include red indicating lamp, protected four heat switch, removable hinged cover, terminal tap for small two ounce etching tool and renewable work plate. All parts are enclosed in a compact, attractive case.

In addition to the standard four ounce etching tool, a small two ounce tool is also available for marking thin delicate parts. Overall size, 7¼ in. x 5⅛ in. x 8½ in.; weight 16 lb.

More Conference-Goers at Rolling Mill Meeting

DAN REEBEL PHOTOS

hard Grace, Assistant Superintendent of Blooming and uctural Mills; William Boyd, Superintendent Structural l Finishing; and R. D. Allard, Superintendent of Bloom- and Structural Mills, Weirton Steel Company.

A. C. Davies, Roll Designer, Burlington Steel Company; Paul Reebel, Mesta Machine Company; Al Werner, Superintendent Hot Strip Mill; and C. H. Williams, Chief Engineer, of Carnegie-Illinois Steel Corporation.

hn Holt, Superintendent No. 3 Mill, and Fred S. High, perintendent Finishing Mills, Crucible Steel Com- ny of America; and P. T. Reynolds, Roll Designer, public Steel Corporation.

Ivor Gardner, Roll Designer, Youngstown Sheet and Tube Company; and Lou Moses, Roll Designer, Bethlehem Steel Company.

J. Barry, Superintendent 110" Plate Mill, Steel Com- ny of Canada; A. C. Davies, Roll Designer, Burling- n Steel Company; and J. W. Forrest, Steel Company Canada.

F. H. Dyke, Assistant General Manager, and George Runser, Superintendent of New Process Mills, Wheeling Steel Corporation; and Fred Horne, Assistant Roll Designer, Youngstown Sheet and Tube Company.

NEW HEAVY DUTY INDUSTRIAL HEATERS MADE IN FOUR SIZES

▲ A new heater for heavy duty applications in industrial heating, air conditioning, vapor absorption, drying and other processing work has been announced by B. F. Sturtevant Company, Hyde Park, Boston, Massachusetts. These heaters possess the maintenance and repair free advantages of the old pipe coil heaters combined with the performance of modern heating surface which has an increased heating capacity of 10 times due to the addition of fins to the heater pipes.

Sturtevant heavy duty steel heaters are constructed of 1 in. standard steel pipe threaded into cast iron headers. Inside these pipes are $\frac{3}{8}$ in. steel pipes which carry the steam from the header, distribute it uniformly to all heater pipes, prevent air binding and provide a non-freeze characteristic.

Wound around the heater pipes are spiral fins made of soft carbon steel strip $\frac{9}{32}$ in. wide and tapered from .035 in. thickness at the edge attached to the pipe to .012 in. at the outside edge. The tapered construction of the fins provides greater heat transfer than with the usual fin of uniform thickness. Absence of crimping also effects marked reduction in resistance to air flow. After assembling, fins and pipes are passed through a metallic bath which assures permanent bonding between pipe and fins, and protects against corrosion.

Above: Complete unit. Right: Cross-section showing header and inner tube construction

Each finned pipe is anchored at one end only, permitting pipes to expand and contract freely, independently of each other. Pipe alignment plates at extreme end, and also at center of all heaters with pipe lengths in excess of 6½ feet insure correct spacing, prevent sagging and assure uniform air flow. All heaters are subjected to a 600 lb hydrostatic test and to 200 lb under steam. Heaters will be tested at 1000 lb hydrostatic pressure if requested.

Standardized steel casings, of heavy gauge galvanized steel, die formed for strength and uniformity are fitted with flanges, template punched, to facilitate assembly to other sections and to duct connections.

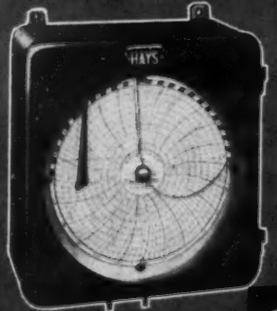
Four sizes of Sturtevant heavy duty heaters are available — 20 in., 25 in., 30 in. and 35 in. width across the pipes. Each size can be furnished with pipe lengths from 2 to 10 feet in 6 in. increments.

A 32-page catalog containing construction details, capacities, dimensions, piping and installation data will be sent by B. F. Sturtevant Company on request.

A Real Aid to PRODUCTION

TYPE CDE-X FURNACE PRESSURE CONTROLLER

SERIES FOT PRESSURE INDICATOR



SERIES OT PRESSURE RECORDER

HAYS
OPEN HEARTH
PRESSURE CONTROL

TONNAGE can be increased through more even operation and even operation also means fuel saving. Automatic control of furnace pressure, rates of fuel and air flow, ratio of fuel to air, constant volume or pressure of oil or gas relieves the operators of many time-consuming details, allowing them to pay more attention to the steel making process.

When desired, the control of these various functions can be handled manually from a centralized panel through remote operation. Hays control is all-electric, simple to install, simple to operate, simple to understand.

The following Hays instruments may be used effectively in combination or separately for the functions indicated.

Type CDE-X Furnace Pressure Controller with external manual adjustment for automatically operating stack damper to hold pressure constant.

Series FOT Pressure Indicator provides an easily read measurement of furnace pressure. Usually connected at furnace roof.

Series OT Pressure Recorder provides daily record (24 hr. chart) of furnace pressure. Shows timing of reversals and each change of pressure made by operator during the heat.

Hays partial or complete instrumentation is a REAL AID TO PRODUCTION. Hays representatives located in the principal cities of the U.S.A. and Canada will gladly supply complete information.

The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

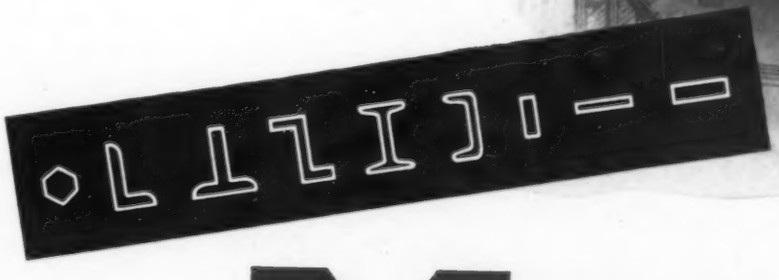
How to Walk Out on a Fire

Below are some of the common Merchant Shapes you'll find in the common Fire Escape. . . . Which, even if it moves indoors, will be an essential part of several billion dollars' worth of new apartments, hotels, factories, lofts, warehouses, theatres, hospitals . . . in the Postwar era.

. . . Reduced to *tonnage* that calls for speed, precision *and versatility* such as you'll find in the new Morgan Rolling Mills.

MORGAN CONSTRUCTION COMPANY
WORCESTER, MASSACHUSETTS

R-123



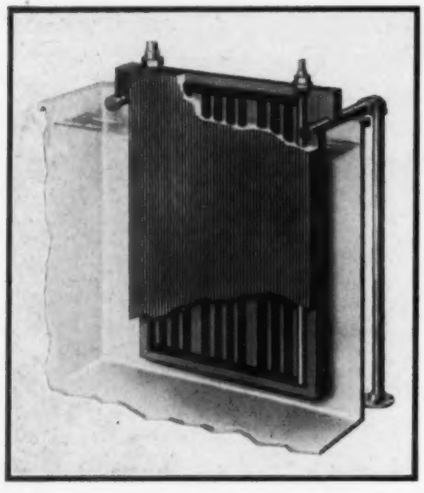
PLAN NOW WITH **MORGAN**

ENGINEERS AND BUILDERS OF ROLLING MILLS . . . WIRE MILLS . . .
GAS PRODUCER MACHINES . . . REGENERATIVE FURNACE CONTROL

HEAT EXCHANGER OFFERS CORROSION RESISTANCE, MECHANICAL STRENGTH

▲ The National Carbon Company, Inc., has developed a compact and sturdy new type of corrosion resistant "Karbate" heat exchanger to meet the need for a chemically inert, mechanically strong heating (or cooling) unit for use in pickling tanks and other metallurgical applications. The "Karbate" material from which the heater is made is an impregnated graphite impervious to liquids under high pressures; it possesses high heat transfer values and is resistant to practically all acids, alkalis and solvents.

The exchangers are of plate type, employing the principle of extended, or corrugated, surface to attain maximum heat transfer area without bulkiness. Installation requirements and economical manufacturing methods caused National Carbon Company to adopt four standard design groups incorporating both parallel and series flow channels, thus making possible 30 different combinations to meet the widest range of heating and cooling requirements.



Small and interchangeable, the units are designed so that they can be readily adapted to various sizes of tanks, they can be mounted in multiple or single units and need little space in the tank.

Some two hundred of the heat exchangers are now in service and producing excellent results. From the tests conducted on those heat exchangers in operation, the following two engineering reports may be regarded as typical. The first installation was of two 10 in. wide x 4 in. thick x 36 in. long plate heaters placed in one end of a non-agitated wooden tank 60 in. long x 36¼ in. wide containing 50 cubic feet (3120 lb) of 1.1 per cent hydrofluoric and 6 per cent nitric acid. The acid liquor was heated from 46.3 F to 167.0 F in one hour using 26 psi gauge steam. The overall coefficient of heat transfer was about 150 Btu per sq ft per ° F per hr. Immersed area of the heaters was 14.0 square feet.

In the second installation, a single heater 94 in. long was placed in one corner of a tank 96 in. long x 48 in. wide x 96 in. deep containing 560 gallons of 35 per cent hydrochloric acid and 1140 gallons of water. Operated on 30 psi steam, thermostatically controlled, the heater required two hours to raise the temperature of the bath from room temperature to 175 F for an overall heat transfer of about 165.

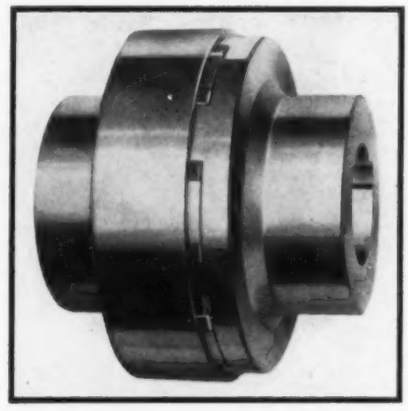
These two examples illustrate the efficiency of the "Karbate" heaters. In certain pickling and plating applications, the heaters, due to their inertness and extremely high heat transfer characteristics, have replaced steam spargers which introduce steam directly into the bath itself for heating purposes. In these processes where spargers have been replaced with the "Karbate" heaters, the problem of acid dilution from condensing steam has been avoided.

Major features of the heat exchanger, however, are its corrosion resistance and mechanical strength, which mean the widest application where corrosive conditions and mechanical shock are inherent to the process. Designed to meet precisely these conditions, the "Karbate" heat exchangers are maintenance free and give a much greater life service than other types of heating units.

FLEXIBLE COUPLINGS FOR HEAVY DUTY

▲ Protection that secures operators against the catching of clothing or incautious handling is embodied in the new L-R type "C" shrouded flexible coupling announced by Lovejoy Flexible Coupling Company, 5009 West Lake Street, Chicago 44, Illinois.

The essential feature of this new protection is the outside steel collar which holds the load cushions in place. An extension of this collar which encircles the coupling, safeguards material and fingers from the heads of the bolts that secure the load cushion retainer. The boltheads are concealed, yet easily and conveniently reached when necessity arises. This improvement effects more compact design with overall smoothness of external surface.



L-R flexible couplings of the type "C" class are designed for heavy duty services from 4.60 to 806 hp at 100 rpm. Individual free-floating load cushions between the rugged jaws, are held in position between an inside steel sleeve, and the removable steel collar. Types are available for directly attaching to flywheel, also drum types and others for rapid disassembly without disturbing drive or driven equipment, etc. Cushions of various materials adapted to the particular service on which the coupling is used, are free to deform to every emergency — for correction of misalignment, protection from shock and vibration, and other transmission troubles which effect both drive and driven machinery. Smooth maximum power-flow is assured.

Cushions are always in sight. In operation half the cushions are idlers (except on reversing load). A new set of cushions is therefore always ready. No shutdowns for changing. No lubrication is required. The coupling is outstandingly noiseless.

Literature and engineering information is now available on the new L-R type "C" couplings on request to the manufacturer.

50TH ANNIVERSARY FOR NATIONAL TUBE, LORAIN

▲ Fifty years of steelmaking, dating from the manufacture of horse-car rails in 1894 to present day "Big Inch" pipeline and World War II bomb pipe, was observed this month at the Lorain Works of U. S. Steel's National Tube Company, world's largest seamless pipe mill.

Lorain trolley rails brought the big mill early fame and the span of 50 years since it was built has witnessed the plant's growth into the only pipe mill in the United States with facilities for producing seamless pipe as big as 24 inches in diameter, the size required for the 1200-mile "Big Inch" petroleum line.

Lorain Works produced ship plates, steel rounds for munitions, pipe for Army cantonments and ships, and numerous other products for the Allies in World War I. Today, 3000 of her employees are fighting in World War II, and the mill's 9000 men and women are busy making bomb pipe for block busters, steel for shells, and pipe of many sizes for ships and other Navy needs.

Through its long, eventful history, the plant has had only four general superintendents — Max Suppes, who supervised the mill's construction, Charles Fell, Earl W. Brown, and the present general superintendent, E. G. Price.

MARKING HOLDER FOR STAMPING TUBING

▲ A new safety peripheral marking holder for stamping around the outer circumference of tubing has been developed by the M. E. Cunningham Company.

The peripheral holder is of all-welded design and the steel stamping figures are constructed of Cunningham's safety steel to insure maximum safety and service. The holder features a hand grip lock, and is equipped with a pointed screw which holds the unit firmly in position for marking.

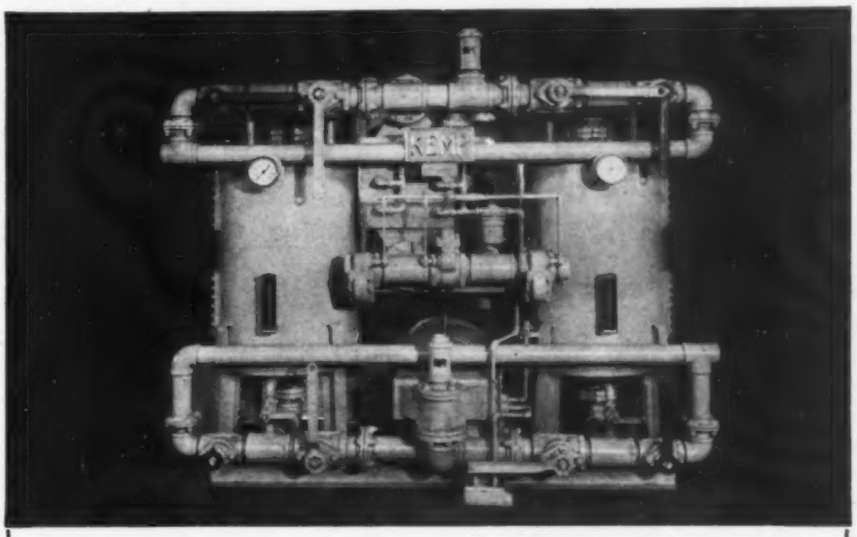
Assuring clean, even impression, the safety peripheral marking holder eliminates separate handling for each character and permits peripheral marking around the end rather than marking along the length of tubes.

This new holder is available with any reasonable number of characters. Further details are available through this publication, or by writing direct to M. E. Cunningham Company, 105 E. Carson Street, Pittsburgh, Pennsylvania.

FOREIGN CONTRACTS FOR FURNACES

▲ Completing its mill at Volta Redonda, Brazil, National Steel Company of Brazil has awarded a contract for engineering and materials for an additional battery of two-hole, modern regenerative soaking pits for use with lean fuel to Rust Furnace Company, Pittsburgh, Pennsylvania. Rust was previously engaged to design, furnish and supervise erection of three two-hole soaking pits, two slab heating furnaces and a splice bar furnace for this company.

Rust has also received a contract for three continuous bloom heating furnaces, each rated at a capacity of 60 tons per hour, for a rail and structural mill for Soviet Russia.



Send us your inquiries—

—for adsorptive dryers

—for inert and atmosphere gas generators

Our ability to furnish equipment to supply your needs and meet specifications is assured by Kemp's extensive experience, equipment, and unsurpassed engineering and fabricating personnel.

Unusual and highly efficient methods of gas application by us to industrial and process heating operations are productive of real benefits.

For technical bulletins, descriptive leaflets and general information, address The C. M. Kemp Mfg. Co., 405 East Oliver St., Baltimore-2, Md.

ARMY E NAVY

KEMP of BALTIMORE

SMALL MACHINE FOR PRECISION TENSILE, COMPRESSION AND TRANSVERSE TESTING

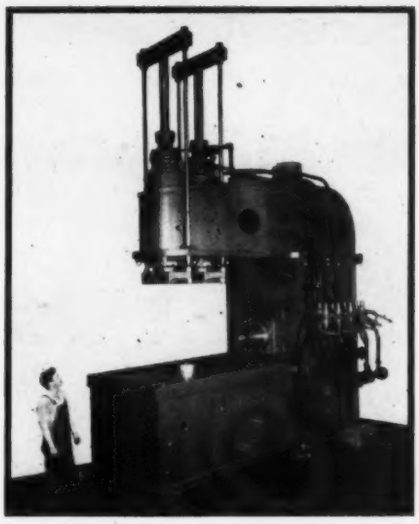
▲ A precision instrument for precision testing, the Dillon tensile tester, manufactured by W. C. Dillon and Company, Inc., 5410 West Harrison Street, Chicago 44, Illinois, is small in size and low in price, making it possible for every company to have tensile testing equipment as an aid to quality control.

Through the use of various accessories, this testing machine will perform a wide variety of work.

Loads are indicated on dynamometer dials, the interchangeability of which affords seven possible loading ranges, from 250 to 10,000 lb maximum pull. Loads are easily applied by means of a counterbalanced handwheel, although the units may be motorized if desired.

Special gripping jaws to suit the nature of the test pieces make it possible to cover a wide range of tensile testing work. Through the use of accessory devices, the tester may also be used for compression testing and transverse testing.

The standard Dillon tester as shown in the accompanying illustration is but 37 in. high, with a base 18 in. x 12 in., and weighs only 132 lb. The machine is easily operated by any average shop worker. Complete information may be obtained from the manufacturer.



HYDRAULIC PRESS FOR FLANGING WORK

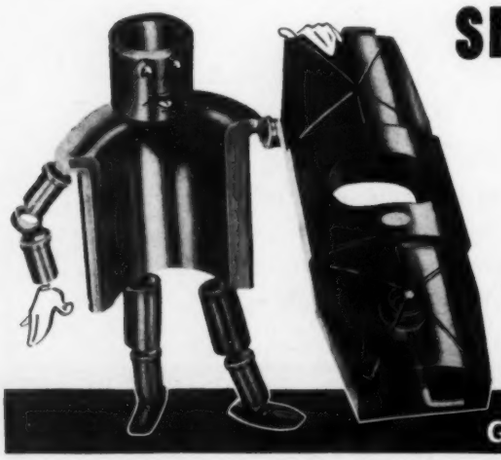
▲ A hydraulic sectional flanging press designed for 1500 psi working pressure has been recently completed by the R. D. Wood Company, Philadelphia 5, Pennsylvania. Enclosed within the three-piece heavy welded steel plate frame are two 10 in. tension columns which carry the full stress of the working load. There are two 16¾ in. diameter vertical main rams; a 14 in. stripper ram and a 15½ in. double acting horizontal ram. The travel of the main rams is 30 in. and each has a capacity of 150 tons. All operating valves are arranged in pulpit form. This arrangement will permit operating each of the two vertical main rams separately or both rams together, thus giving a total capacity of 300 tons.

The stroke of both the horizontal ram and the stripper ram is 24 inches and the capacity 115 tons. Maximum daylight opening is 45 inches. Width of table, 8 feet. The table has four tee slots, machined from the solid, running from front to back and is machined for insertion of stripper cylinder.

INDICATING FLOWMETERS OFFER UNUSUAL FEATURES

▲ Several important features claimed to be exclusive are listed by Cochrane Corporation, of Philadelphia, in announcing series R-100 Rotameters. These meters are of the indicating area meter type, covering sizes from ⅛ in. to 3 in., with both free and guided floats. Floats may be viscosity or density compensated. Metering tubes are of extra heavy wall Pyrex borosilicate glass formed on mandrels, annealed, polariscope inspected and check-gauged by precision ball test. Features include:

1. Spring stop floats, to prevent damage to float by sudden surges of liquid.



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The GATKE Invention that Revolutionized Universal Coupling Performance . . .

- **10 times longer service.**
- **Eliminate Socket Scoring and Wear.**
- ***Avoid costly machine shop work.***
- **End destructive vibration.**
- **Stop pounding noises.**
- **Prevent Grease slinging.**
- **Made to fit without machining for all sizes and types of UNIVERSAL COUPLINGS.**
- **Information on request.**

Gatke MOULDED FABRIC Bearings

GATKE CORPORATION - 228 N. La Salle - CHICAGO

TOP CHARGING · SWINGING ROOF · FOUR POINT ROOF SUSPENSION · INTEGRATED CONSTRUCTION OF ROOF OPERATING MECHANISM

With smooth performance, SWINDELL Electric Arc Melting Furnaces are doing a dependable war-time job daily . . . helping make new steel production records!

SWINDELL-DRESSLER Corporation

DESIGNERS AND BUILDERS OF MODERN INDUSTRIAL FURNACES

PITTSBURGH, PA.

INVEST IN WAR BONDS

2. High pressure stuffing boxes, permitting use of corrosive liquids under high operating pressures.
3. Single external adjustment of stuffing boxes by wrench, instead of taking up successively a number of bolts or screws.
4. White-backed metering tube for easy reading.
5. Interchangeable calibration scales for quick and inexpensive change from one service to another.
6. Constant tension guide rod is anchored in ends of glass tube instead of in end fittings. It can therefore be more accurately centered and its tension will be unchanged by repeated stuffing box adjustment.
7. For test accuracy work, guide rod can be supplied with spring loading feature to secure ideal precision of alignment.

The line of Rotameters covers a considerable range of types, including free float and liquid float types, extra length guided float type, dashpot type for pulsating flows, panel mounting type, portable type, Rotameters for opaque fluids, Rotameters for vapors containing condensibles, Rotameters with remote indicators, recorders, integrators, automatic controllers and automatic proportioners. A catalog, publication R-100 is available.

RECTIFIERS WITHSTAND SHORT HIGH OVERLOADS

▲ Selenium rectifier power supply units of 1, 5 and 10 amperes at 115 volts, d-c, designed for use in the operation of magnetic equipment, d-c motors, relays, circuit breakers, carbon arc lamps, battery chargers, and other applications have been added to the line of power supply equipment manufactured by Federal Telephone and Radio Corporation, Newark, New Jersey. In addition to these sizes, Federal offers individualized design and manufacture where equipment for other capacities is required.

The new units are designed for wall or bench mounting with no special connections needed. They are equipped with a 6-foot input lead with male connector and a standard convenience receptacle for the output. The 10-ampere unit is furnished with an 11-point selector switch for maintaining 115 volts from no load to full load.

Powered by convection-cooled Federal selenium rectifiers, these 1, 5 and 10 ampere units are conservatively rated to assure trouble-free performance over a long period. As these metal-plate rectifiers have no moving parts, they are not affected by normal vibrations, and operate at high efficiency over a wide range for an unlimited long life, with no maintenance expense. The units can stand as much as ten times their rated loads for short periods of time without damage.

Descriptive literature with ratings and engineering data is available.

CIRCUIT BREAKERS FOR TEMPORARY CIRCUITS

▲ Controlling temporary power and light circuit through a central unit protected by circuit breakers is now possible with a newly designed "Scatter Box" perfected by the Square D Company, 6060 Rivard Street, Detroit 11, Michigan.

Designed primarily for shipyards and aircraft plants where a number of temporary circuits must be set up and torn down quickly, the scatter box is applicable anywhere the same requirements are met. The Square D device is built for from four to eight circuits with or without neutral. Circuits are protected by 15 ampere, 115 volt single pole, type MO multibreakers (circuit breakers) although 20 or 25 ampere breakers can be substituted.

The hinged cover of the scatter box can be padlocked and openings for plug receptacles similar to Hubbel No. 7557-G are provided. One 1 in. knockout in each end is included and the box has a pair of ears for hanging. Receptacles or internal wiring are not provided.

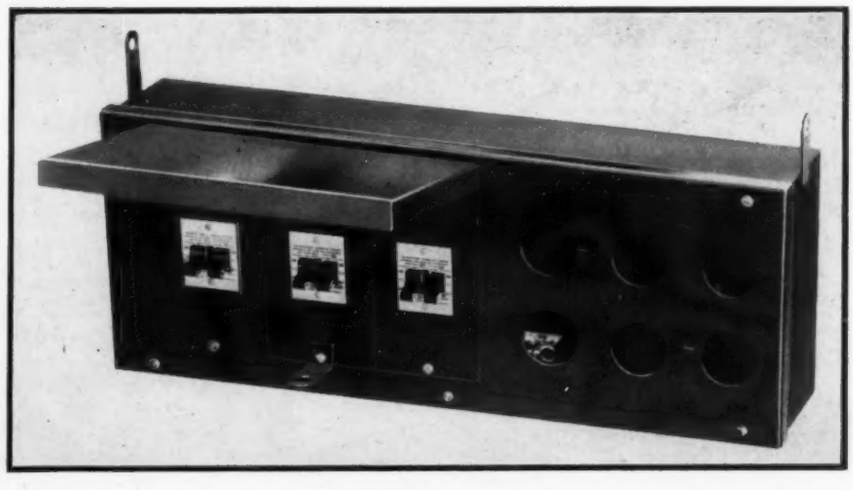
EXPANDER DRIVER GETS INTO DIFFICULT CORNERS

▲ Since it is difficult to reach many spots in present day boilers with tube expanders driven by portable drills, flexible shafts, or similar driving units, Invincible Tool Company has developed an angle tool attachment known as the Invincible Boiler Tube Expander-Driver. This new tool provides the link between the tube expander and the driving unit, making it easy to get at "hard-to-reach" spots.

Invincible Expander-Drivers work in right- or left-hand corners. They are made in two standard sizes with ¾ in. and ½ in. square driving chuck. A special ball thrust take-up takes the thrust both forward and reverse, making for smooth, free-running operation. All thrust action is taken directly on these bearings, allowing instant reversal of driving direction. These tools are ruggedly built for heavy-duty service.

Complete details may be secured by writing this publication, or direct to Invincible Tool Company, Empire Building, Pittsburgh 22, Pennsylvania.

The scatter box idea is not new. They were used extensively on the theatrical stage in the early part of the century and may even have an earlier history; but their application to mass production of aircraft ships, etc., is as recent as the war. Square D Company engineers believe they will find general usage in the construction of housing projects, commercial and industrial building and other applications where temporary distribution of comparatively light loads are required.



TREATED TIMBER TIES SHOW EXCELLENT LIFE

▲ A 40 per cent monthly savings in tie costs by mines using Koppers Ar-Moored steel ties in preference to untreated timber ties, is revealed in a new eight-page booklet just released by Koppers Company, Wood Preserving Division, Pittsburgh.

Koppers Ar-Moored ties are constructed with a creosote pressure-treated oak base to which is fitted a Bethlehem Steel mine tie secured to the wooden base with special nuts and bolts. Available in two, three, and four-inch bases for a variety of mine haulage tasks, Ar-Moored ties are furnished with either staggered clips or outside stationary clips. Generally, staggered clips are more readily applied to curved rails in working sections while outside stationary clips are best fitted for main haulage.

Particularly advantageous where expensive mechanical cutting and hauling machines are used, Ar-Moored ties combine the benefits and best utility of treated wood and steel ties in one unit to provide high-capacity track to match high-capacity equipment.

Koppers Ar-Moored ties are suitable for use in temporary track for working sections and for main line haulage, inside the mine or out. When sections are worked out, Ar-Moored ties can be quickly recovered and relaid without bending, distortion ,or spike-kill. They maintain track gauge permanently eliminating the need for gauge rods or tie forks when track is being laid. Mine accidents and injuries are avoided as the track stays in line "ballasted" with wood.

Engineers, construction men and mine operators desiring additional information should write to Koppers Wood Preserving Division, Pittsburgh (19) requesting a copy of "Ar-Moored Ties for High Track Capacity."

STEAM JET SPEEDS PICKLING, PROCESSING

▲ The Heil Engineering Company, 12901 Elmwood Avenue, Cleveland, has developed a new type of steam jet for tank processing of bar metals, wire, and continuous sheet or strip, furnished in flanged sections which can be coupled together to provide any desired length, and to extend the agitating and heating effect to any part of a tank.

Designed to speed pickling or processing and to provide more complete agitation and more uniform heating, this jet can be adapted to square, rectangular or round tanks. Boiling temperatures can be attained, at which these rugged jets will give unusually long service. Sections are usually made in lengths of about 10 feet, and are coupled with lead bolts, with a blind flange to close the open end. Nozzles are spaced along the tank bottom on 15 in. centers unless otherwise specified by the user.

The series of nozzles along the entire length of the tank creates a rolling, agitating effect similar to a barrel roll, causing the liquid to circulate above and around the parts immersed. The effect is increased by placing jets on either side or all around the bottom of the tank, with nozzles set at angles to produce the maximum rolling effect.

Type WMK Enclosed Safety Switch

CONDULETS

are **rain-tight.** You can use them in **both** indoor and outdoor non-hazardous locations. Also suitable for Classes III and IV hazardous locations. (NEMA Types 3 and 5)

Feraloy cases. Strong and durable. Four sturdy mounting feet. Many possible conduit arrangements for both horizontal and vertical through feed.

Safety. Positive interlock prevents opening the case unless switch is "off." Dead front switch held in "off" position while case is open.

Padlocks.
1. Cover may be padlocked to prevent unauthorized entry.
2. Operating handle may be padlocked "on" or "off."

Threaded operating shaft. Bearings permanently lubricated. Resists corrosion. Prevents the entrance of dust and moisture.

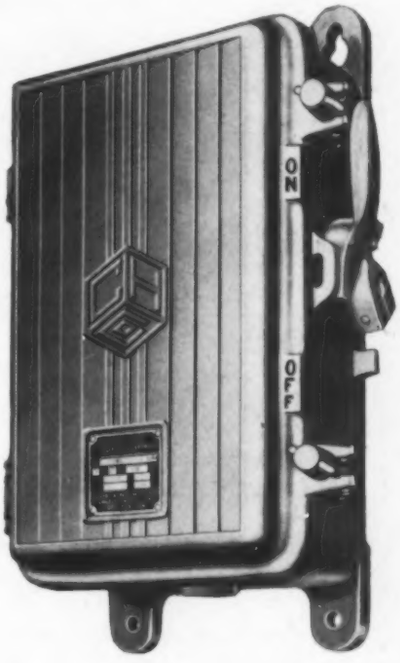
Switches. Quick make and break mechanism. Double break, reinforced, positive pressure-type blade and jaw construction. Positive pressure fuse clips. Combination solder or solderless wire lugs.

30, 60, 100 or 200-Ampere.
1 to 50-H.P

125 to 600-volt, A. C.

2 or 3-pole, fusible or fuseless.

Listed in Condulet Catalog No. 2500, Section 50, Page 20A.



CONDULETS are manufactured only by CROUSE-HINDS

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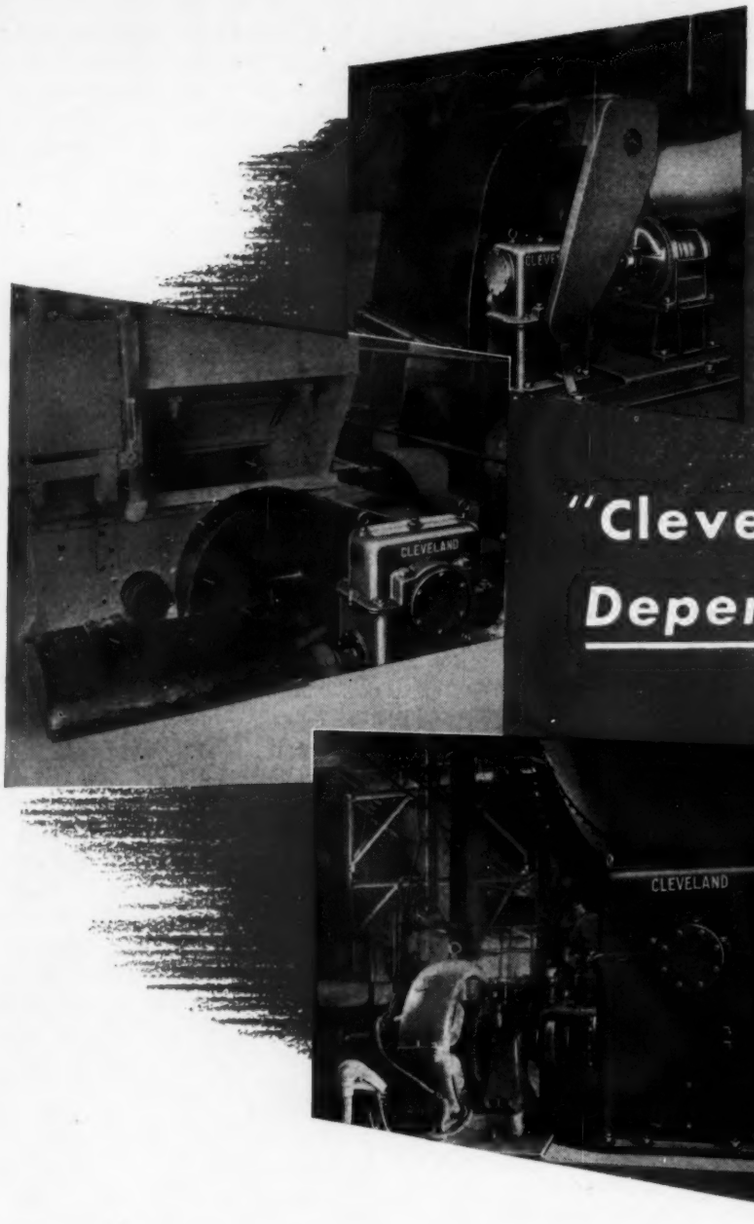


For your Crushing-Grinding-Mixing Operations...

"Clevelands" insure Dependable Power!

To safeguard your costly investment in machines *and*—

To insure that your continuous processes will *really* be "non-stop"—

Install Cleveland Drives on your new Crushers—Grinders—Mixers—Conveyors—in fact on *all* equipment where continuous operation is vital.

Reliable performance since 1917 assures that the good Cleveland Worm Gear Speed Reducers you install for round-the-clock operation will stay faithfully on the job for years to come. (After 15 years or even longer owners frequently report "not a minute lost for repairs or parts replacement.")

Cleveland builds fine Worm Gearing exclusively. Capable Engineers will gladly help you to apply one or more of Cleveland's basic, standardized Types to your particular equipment.

The Cleveland Worm & Gear Company, 3278 East 80th St., Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication

In Canada: PEACOCK BROTHERS LIMITED

CLEVELAND WORM GEAR SPEED REDUCERS

New Literature

▲ "Basic Open Hearth Steelmaking" published by the American Institute of Mining and Metallurgical Engineers, 29 West 39th Street, New York, is the result of work by the Institute's committee on physical chemistry of steelmaking. This book deals comprehensively with the arts and science upon which the manufacture of open hearth steel is based, bringing much scattered information together in one volume and filling a definite gap in our technical literature. Divided into two parts, practice and theory, the volume should prove valuable as a handbook for furnace operators, as a reference for practicing metallurgists and as a textbook for students and teachers.

▲ A second edition of "Control of Electric Motors," by P. B. Harwood, manager of engineering, Cutler-Hammer, Inc., Milwaukee, Wisconsin, has just been published by John Wiley and Sons, Inc. Widely used as a text in colleges and universities and for training men in industry, the revision was made in response to many requests for more information about synchronous motor control and variable voltage control. Complete chapters have been added on these subjects. Many new tables giving the ratings of motors and controllers have been included. Text and illustrations have been revised to conform to latest practice and to include recent developments. The general arrangement of the book has also been radically changed.

▲ Booklet DB-9100-1, published by the Clark Controller Company summarizes the company's d-c magnetic control systems for hoist, bridge and trolley motions of cranes, and contains much valuable information for users of crane control. A comprehensive description, with operating data, for their bulletin 9135 Form M hoist controllers and bulletin 9136 bridge and trolley controllers is given. For copies, address the Clark Controller Company, 1146 East 152nd Street, Cleveland 10, Ohio.

▲ To show how war plants have been applying Rayotubes and Micromax equipment to important new temperature-measuring jobs, the Leeds and Northrup Company has just revised its Micromax rayotube pyrometer catalog.

Embodying, in this forty-eight page edition, basically the same engineering descriptions as were presented in the 1941 publication, it includes for the first time equipment being used to measure the temperature of molten cast iron, electric salt pots and blast furnace stove domes.

The publication should be of special interest to anyone who may not have a copy of the earlier edition or to anyone who has use for the very latest information.

For a copy, write to Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pennsylvania. Ask for Catalog N-33B — "Micromax and Speedomax Rayotube Pyrometers."

▲ A new, fifteen page bulletin has just been released by Whiting Corporation, Harvey, Illinois, dealing with the newest addition to their long list of foundry equipment. This is the Whiting Hydro-Arc Electric Furnace. Covering the application, design, method of operation, and advantages of the electric melting furnace, this two-color bulletin is illustrated throughout with photographs and diagrams. Free copies of this bulletin will be mailed upon request.

▲ A new chart of electrical symbols for power, control and measurement, both in one line and complete wiring diagrams, is included in bulletin 4403 published by the I-T-E Circuit Breaker Company, 19th and Hamilton Streets, Philadelphia 30, Pennsylvania. All symbols shown are American standard.

This bulletin is only 8½ in. x 11 in. in size, allowing it to be kept in a desk drawer, but can be unfolded to 17 in. x 22 in. for use as a wall chart or spread under a glass table top. The symbols chart is in blueprint style and lacquered to withstand frequent handling without soiling.

Containing more than 500 symbols and switch sequence tabulations, including over 100 for motors and other rotating machines alone, the chart is one of the most complete ever published. The I-T-E Company offers it as a service to the electrical industry in promoting the use of standard symbols which will be quickly recognized by all users of wiring diagrams.

▲ Tube Turns, Inc., of Louisville, Kentucky, has recently published a handy pocket-size dimensional data chart which gives complete quick-layout information on every Tube-Turn welding fitting and flange. Printed attractively in two colors these 9 in. x 24 in. charts are ideal for spreading out on a drawing board or desk, or they can be folded up like a railroad timetable into a 9 in. x 4 in. folder and slipped into a pocket. Just make the request on a company letterhead and one of these charts will be sent free of charge.

▲ Air Reduction, manufacturers of gas and arc welding equipment and supplies, are offering a free pocket-sized, slide-type guide that shows proper tip sizes, gas pressures, and other data required for machine gsa-cutting steel of various thicknesses, with two of Airco's most widely-used machine gas-cutting tips — Airco "45" and "124."

By setting the slide to one of the known factors — such as steel thickness — the gas-cutting machine operator may immediately determine the correct tip size to use, oxygen and acetylene pressures required, estimated gas consumption, width of kerf, and average cutting speed to be expected. The back of the guide lists helpful hints for machine gas-cutting operators, including pointers on setting up, piercing starting holes, making heavy cuts, etc.

Free copies of this handy guide may be obtained by writing to the main office of Air Reduction, 60 East 42nd Street, New York 17, New York, or to any of the company's branch offices throughout the United States.

▲ The Youngstown Miller Company, Sandusky, Ohio, announce that their bulletin YM-700 covering their new robot oil reclaimer is now available.

The Robot employs the process that this company has used in batch oil reclaimers for over ten years — with the new feature that operation is now automatic and continuous.

These units are capable of restoring all kinds of lubricating, hydraulic, cutting and vacuum pump oils so that the reclaimed oil can be re-used in the same manner and place as the new oil.

Operators of Diesel engines will find that a single Robot can take care of all their Diesel engines. They have the added assurance that the Robot can remove fuel dilution and moisture and keep their engines clean.

Capacities range from 4 gallons per hour to 300.

▲ The latest Manual of A. S. T. M. Standards on Refractory Materials with other pertinent information and data is the fifth sponsored by A. S. T. M. Committee C-8 on Refractories. It includes new standards for air setting refractory mortars, fireclay plastic refractories both for boiler and incinerator services, methods of test for measuring the shrinkage, spalling, and workability index of fireclay plastic refractories, and a method for measuring the thermal conductivity of insulating fire brick.

Seven specifications on refractories for various types of service are given in the book. There are two classifications of materials and the remaining 16 standards give widely used methods of testing, some specifically for fireclay refractory brick, others for fireclay plastic refractories, some for insulating fire brick and others for various types of refractory materials. The latter includes tests to determine P. C. E., permanent linear change, cold crushing strength, warpage, porosity, true specific gravity.

An important part of the book is a group of industrial surveys which are a most important contribution to the literature in this field. These surveys describe the operations carried out in the furnaces, the types of refractories used in them, and outline the conditions which affect the life of the refractories. A list follows: Open-Hearth Practice; Electric Furnaces Used in Steel Manufacture; Malleable Iron Industry; Copper Industry; Lead Industry; By-Product Coke Ovens; Lime Burning Industry; Glass Industry; Portland Cement Industry; Stationary Steam Boilers.

Other data in the manual cover standard samples of refractory materials for chemical analysis, and for pyrometric cone equivalent.

This 210-page publication, which is particularly valuable to those who use refractories, can be obtained from A. S. T. M. Headquarters, 260 S. Broad Street, Philadelphia 2, Pennsylvania, at $1.50, heavy paper cover; cloth, $1.75. Reduced prices on quantities are in effect.

▲ To their many foundry friends, Whiting Corporation, Harvey, Illinois is offering a valuable, pocket-size booklet titled, "Useful Information." Charts and diagrams pertaining to many and varied foundry operations are included. Weights of various materials, ladle capacities in both iron and steel, melting points of metals and alloys, and a color scale for temperatures are but a few of the important subjects covered. Copies of this booklet will be sent upon request with no obligation.

▲ Bulletin No. 26-B of Trico Fuse Manufacturing Company, 2948 North 5th Street, Milwaukee 12, Wisconsin, illustrates and describes a modernized, streamlined oiler with a crystal-clear, re-inforced plastic reservoir that is 50 per cent lighter in weight and has no gaskets to leak. The dust-proof style has an oil filter that can be removed for easy cleaning in less than five seconds without tools, mess or waste of time. Write for your free copy.

▲ National Electrical Manufacturers' Association announce the following new publications:

"Lightning Arrester Standards," Publication No. 44-89.

This is the first publication issued by N. E. M. A. pertaining to lightning arresters. It is a reference manual of standards which provides practical information concerning the manufacture, test and performance of lightning arresters.

The manual includes general standards which embrace the classification of types, uses, rating, and service condition standards. It also covers methods of test and design tests. Rating and manufacturing standards for several types of lightning arresters are included, as are also all definitions necessary to the scope of the manual.

Consulting engineers, manufacturers and users of lightning arresters should find this manual useful. 36 pp., 8½ in. x 10 in., $1.00.

"Mining and Industrial Locomotive Standards," Publication No. 44-96.

This publication is a manual of standards containing information on special types of locomotives. It deals with trolley-type, storage-battery, and combination types of mining locomotives, and industrial locomotives of the trolley-, third-rail, storage-battery and combination types.

The list of other related standards rounds out the usefulness of this manual.

This up-to-date manual supersedes Publication No. 38-48, released in 1938. 23 pp., 8½ in. x 10 in., $.75.

Universal Joint Slippers of Ampco Metal stand up . . .

. . . where ordinary bronzes fail
Where ordinary bronze chews apart quickly under the severe pressure and shock, and the abrasive action of the powdered steel scale, spindle bearings of Ampco Metal give excellent service — because they are harder, stronger, tougher. . . . For this and other applications in modern high-speed and continuous mills, it pays to specify Ampco Metal. Widely used in leading plants. Consult your nearest Ampco Field Engineer, or write for Engineering Data Sheets 38 and 73. Ampco Metal, Inc., Dept. IS-6, Milwaukee 4, Wisconsin. Ampco Field Offices in all principal cities.

Metal
The Metal without an Equal

ROCKBESTOS A.V.C.

Takes "SPECULATION" out of Wire Performance in HOT Locations

THE ROCKBESTOS CONSTRUCTION THAT PROVIDES LONG WIRE LIFE

Rockbestos A. V. C. Power Cable, at right, and similarly insulated Motor Lead Cable (Underwriters' and Nat. Elec. Code, Type AVA) has a maximum operating temperature rating of 110° C. (230° F.) and this permanently insulated construction:

1 The conductor is perfectly and permanently centered in helically applied insulation.

2 Felted asbestos insulation, impregnated with heat, flame and moisture resisting compounds, withstands conductor heating overloads and won't dry out, bake brittle or burn.

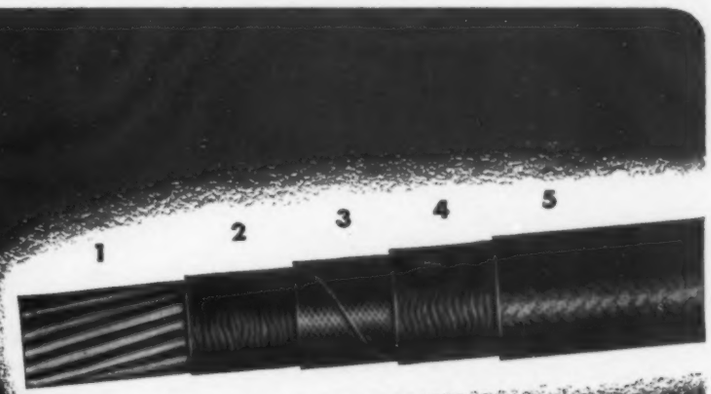
3 Lubricated varnished cambric for high dielectric strength and added moisture resistance, protected from heat, flame and oxidation between two felted asbestos walls.

4 Outer felted asbestos wall, also impregnated with heat, flame and moisture resistant compounds, serves as an effective barrier against high ambient temperatures and flame.

5 A tough, rugged asbestos braid, resistant to heat, flame, moisture, oil, grease and corrosive fumes.

One of 122 different wires and cables developed for severe operating conditions by Rockbestos.

WON'T bake brittle, bloom, burn or rot. RESISTS moisture, oil, grease and fumes.



Take an electrical circuit that runs around or next to a hot strip mill, soaking pit, forging press, steam tunnel, lehr, kiln, etc.,—and you're really "speculating" with wire performance *unless* the wire used has an insulation that will stand up under the high operating temperatures.

Rockbestos A. V. C. takes the "speculation" *out* of wire performance in hot spot locations. Its *permanent asbestos insulation* provides trouble-free circuits because it resists heat, flame, oil, grease, moisture and corrosive fumes, and won't bake brittle, bloom, flow, rot or crack under heat or severe operating conditions.

Put performance insurance in your circuits . . . wire with *permanently* insulated Rockbestos A. V. C. There are 122 standard constructions available to meet practically every service requirement When inquiring or ordering, please furnish CMP allotment number or symbol and certification. For complete information and samples, write nearest branch office or:

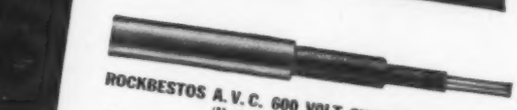
ROCKBESTOS PRODUCTS CORPORATION, 945 Nicoll Street New Haven 4, Conn.

FOR VICTORY BUY WAR BONDS

ROCKBESTOS A.V.C.

The Wire With Permanent Insulation

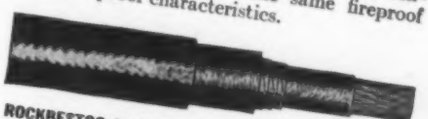
NEW YORK, BUFFALO, CLEVELAND, CHICAGO, PITTSBURGH, ST. LOUIS, LOS ANGELES, SAN FRANCISCO, SEATTLE, PORTLAND, ORE.



ROCKBESTOS A. V. C. 600 VOLT SWITCHBOARD WIRE (Underwriters' Type AVB)

Sizes No. 18 to No. 4/0 AWG with varnished cambric and impregnated asbestos insulation and gray, black, white or colored flameproof braid.

Combine fire insurance and fine appearance in your switchboards with Rockbestos Switchboard Wire. It is fireproof and will not dry out under heat. Sharp, clean bends can be made without cracking as the asbestos wall acts as a cushion under the braid. Rockbestos AVC Hinge Cable and Switchboard Bus Cable have the same fireproof and heatproof characteristics.



ROCKBESTOS A. V. C. 600 VOLT MOTOR LEAD CABLE (Underwriters' Type AVA)

Size No. 18 AWG to 1,000,000 CM insulated with two walls of impregnated asbestos and a high-dielectric varnished cambric insert, with a heavy asbestos braid overall.

Heatproof, fireproof, greaseproof and oilproof, will not dry out and crack, won't burn or carry flame, and remains permanently flexible. For coil connections, motor and transformer leads where extreme heat and fire hazards are encountered as in steel mills, etc.

ROCKBESTOS ALL-ASBESTOS FLEXIBLE CORD

Sizes No. 10 to 18 AWG with two or three conductors insulated with felted asbestos, covered with asbestos braid. Also in A. V. C. (asbestos and varnished cambric) high-dielectric constructions.

This heat-resisting flexible cord is ideal for high-wattage lighting units, floodlights, blue-print machines, apparatus, etc., which require a heavy duty, enduring cord. For moisture-resistant construction specify the A. V. C. type. Labeled cord with polarized conductors if desired.

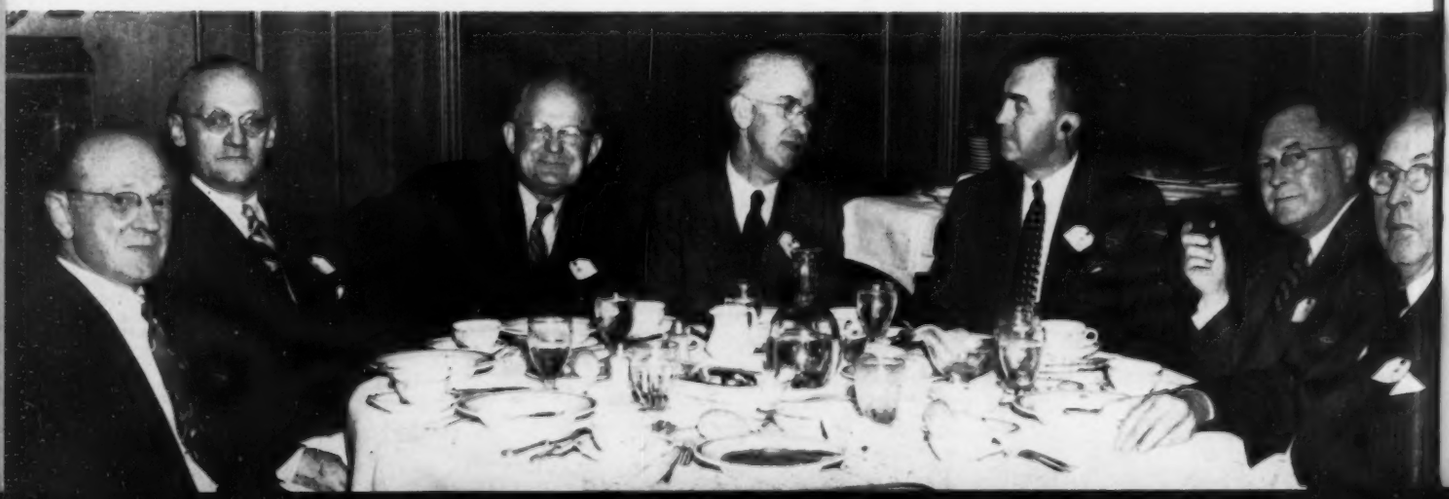
A. I. S. E. Starts Buffalo District Sectio

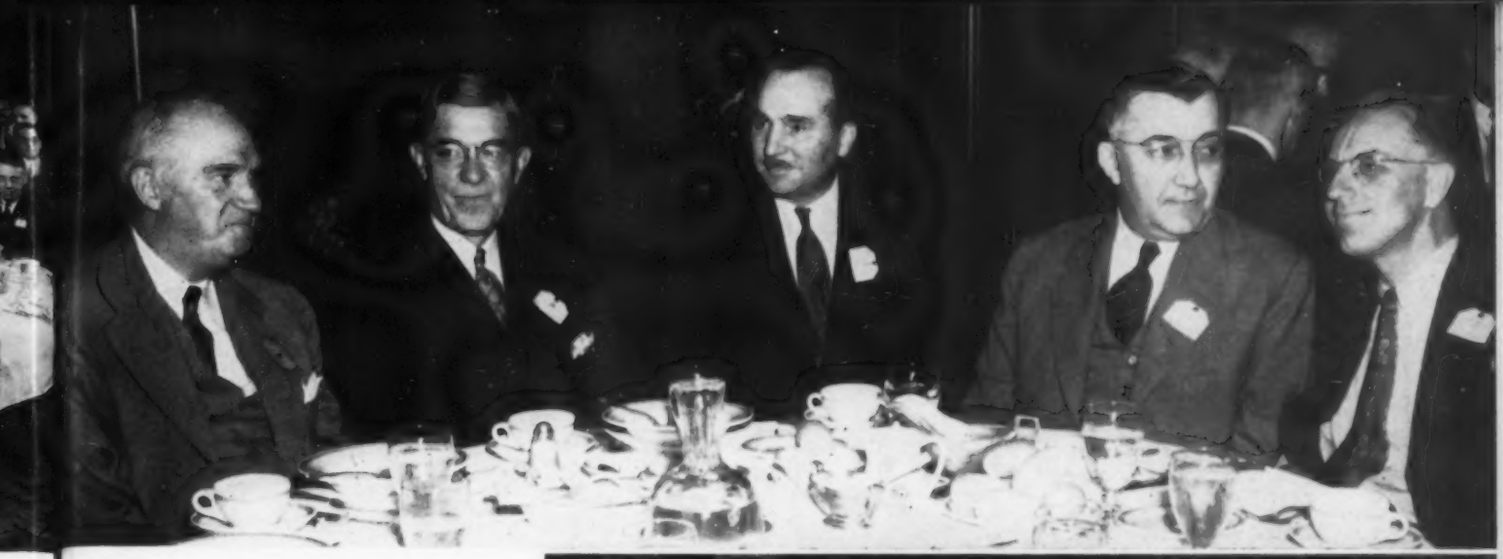
G. E. Reiser, assistant lubrication engineer, Bethlehem Steel Company John F. Black, assistant works manager, Atlas Steels, Ltd. and H. C. Lindberg, engineer, General Electric Company.

C. H. Heist, general superintendent, Hanna Furnace Corporation, C. L. McGranahan, assistant general superintendent, Jones and Laughlin Steel Corporation, L. R. Milburn, electrical engineer, Great Lakes Steel Corporation, L. O. Morrow, manufacturers' agent, Philadelphia, Pennsylvania, R. H. Davis, president, Atlas Steels, Ltd., Wm. B. Wallis, vice-president, Pittsburgh Lectromelt Furnace Corporation and G. W. Bickerton, consulting engineer, Laminacao Nacional de Metais.

An attendance of 140 members and guests marked the opening meeting of the new Buffalo District Section of the Association of Iron and Steel Engineers, at Hotel Statler, Buffalo, New York, on May 29th. The group was addressed by C. L. McGranahan, A. I. S. E. president, and John H. Graft acted as chairman pro tem. The selection of section officers resulted in the election of John F. Black as chairman, George E. Reiser as vice-chairman, and H. C. Lindberg as secretary. The executive committee also includes H. E. Davis, Republic Steel Corporation, C. J. Porter, Steel Company of Canada, P. F. Kinyoun, Bethlehem Steel Company, and H. O. Wicks, Jr., Hanna Furnace Corporation.

Speakers at the meeting were Wm. B. Wallis and G. W. Bickerton, who discussed the steel industry of South America. Visitors were present from Cleveland, Detroit, Philadelphia, Pittsburgh, Sharon, Welland, Niagara Falls and Toronoto.





4 — F. C. Farrel, district manager, Republic Steel Corporation, Brent Wiley, managing director, A. I. S. E., R. C. Jayne, vice-president, Atlas Steels, Ltd., J. H. Graft, assistant district manager, Republic Steel Corporation and W. W. Spanagel, Cleveland district manager, Reliance Electric and Engineering Company.

5 — A. M. Cameron, roll designer and C. P. Hammond, superintendent of mills and billet department, Atlas Steels, Ltd., A. F. Wolf, foundry superintendent, Wm. Magrun, chemist, F. J. Hillwig, general superintendent, M. L. Windle, chief chemist and P. J. Britt, assistant superintendent, of Simonds Saw and Steel Company, Lockport, New York.

6 — M. Shrifs, roller, R. M. Boyer, master mechanic, W. G. Smith, assistant superintendent, H. R. Turner, master mechanic strip mill, all of Bethlehem Steel Company, Buffalo, New York. J. A. Munhall, vice-president, Buffalo Electric Company and S. Grand-Girard, superintendent electrical and mechanical department, Sharon Steel Company.

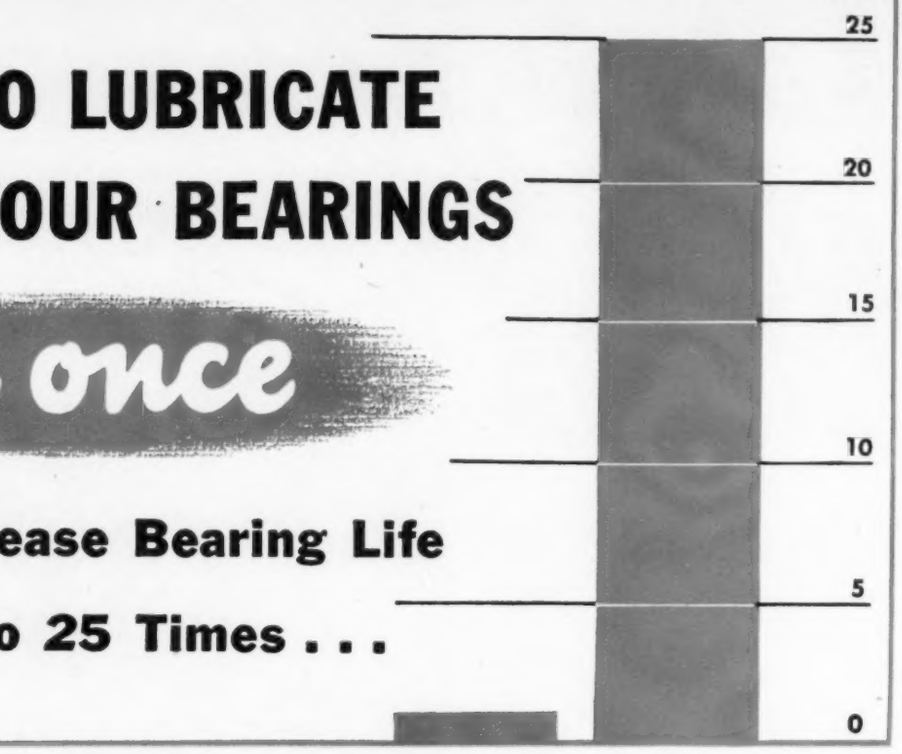
7 — R. K. Glass, assistant chief metallurgist, Republic Steel Corporation, R. P. M. Carmody, Clark Controller Company, Herman Sandberg, assistant superintendent of maintenance, J. D. Dickerson, chief metallurgist, Henry E. Davis, superintendent maintenance, J. L. Edwards, superintendent finishing mill, R. I. Moissinac, roller and J. Victor Halldin, roll designer, of Republic Steel Corporation, Buffalo, New York.

8 — B. L. Donahue, Buffalo district manager, Cutler-Hammer, Inc., T. O. Zittel, assistant electrical superintendent, E. G. Ball, H. A. Carter, superintendent roll department, F. S. Eckhardt, chief engineer, H. K. Wilson, superintendent mechanical department, J. E. Sowers, general foreman electrical department and R. W. Graham, electrical superintendent, all of Bethlehem Steel Company, Buffalo, New York.

HOW TO LUBRICATE ALL OF YOUR BEARINGS

at once

. . . and Increase Bearing Life 5 to 25 Times . . .



Positive lubrication by the Farval Centralized System prolongs the useful life of your bearings from 500% to 2500% beyond the average for hand oiling. *In addition,* Farval eliminates down time required for bearing changes.

The Farval Centralized System forces lubricant under pressure from a Central Pumping Unit to *every* bearing, regardless of location —does a complete job in less than one minute with machines in full operation. Farval will cut your lubricant consumption by 75% —will save Time—save Men—prolong the life of your machines—increase your production and reduce your costs.

Install Farval as you convert. Wire today.

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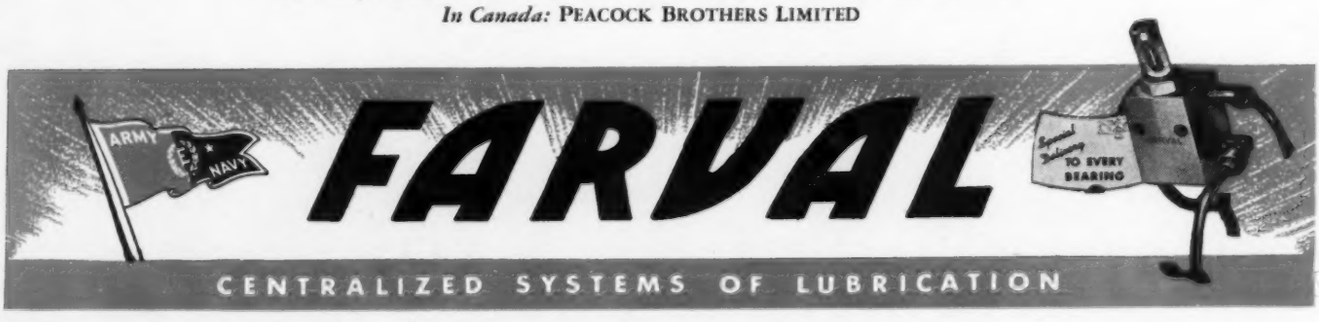

Personnel News

C. L. Kingsbury was recently elected director, vice-president and general manager of the Rustless Iron and Steel Corporation, Baltimore, Maryland.

Mr. Kingsbury was graduated from Stevens Institute of Technology as a mechanical engineer in 1913. He has had wide experience in the field of engineering and industrial management. His first job was as machinist's apprentice for the Union Pacific Railroad. He then became a tool designer for a large company manufacturing electrical equipment, later becoming a foreman of the company's assembly shop. Afterward, he became test engineer for the General Electric Company. In 1917, he entered the armed forces, and ultimately was commissioned captain in the ordnance department. Stationed at Watervliet Arsenal, he supervised various shops manufacturing guns.

C. L. KINGSBURY

Following the war he spent several years with a large industrial engineering organization and the American Linseed Company.

In March, 1927, Mr. Kingsbury was appointed controller of The American Rolling Mill Company which position he resigned on May 22, 1944.

Maurice N. Trainer, first vice-president of the American Brake Shoe Company, was elected a director of the company at the Board meeting held on May 10 in New York. Mr. Trainer has been vice-president of Brake Shoe since 1933, and was elected first vice-president on October 13, 1943. He has been president of the company's Brake Shoe and Castings Division since 1939.

A graduate of the University of Pennsylvania in 1910, Mr. Trainer joined Brake Shoe in 1916 as a brake shoe inspector. From this service he went into sales and sales engineering, and in 1926 was made vice-president of American Malleables Company and also of American Brake Materials Company. In this latter position Mr. Trainer devoted his attention to adapting the company's long experience in railroad braking to the development of brake materials for the automotive industry. After completing this assignment he returned to the sales, production, and improvement of railroad brake shoes.

G. N. HERMAN

G. N. Herman, who has been vice-president of the Continental Foundry and Machine Company since 1934, has been elected president, succeeding **J. T. Osler,** formerly president and chairman of the board. Mr. Osler remains chairman of the board and chief executive officer. **M. G. Sternberg,** who has been vice-president in charge of operations since 1940, was elected executive vice-president of the company.

J. F. Spellacy, former superintendent of the 77-inch hot strip mill at the Otis Works of Jones and Laughlin Steel Corporation, has been appointed to the newly created post of staff engineer. **B. F. Scott** has been appointed superintendent of the 77-inch hot strip mill, succeeding Mr. Spellacy. **W. J. McNally** has been appointed steel order supervisor, succeeding Mr. Scott, and **Laird P. Lias** has been appointed assistant superintendent of the Riverside open-hearth department.

Julian F. Gordon has been made assistant manager of sales, stainless steel division, of Carnegie-Illinois Steel Corporation. A graduate of the Wharton School of Finance and Commerce at the University of Pennsylvania, Mr. Gordon was formerly employed by Republic Steel Corporation and the American Iron and Steel Institute. He came to Carnegie-Illinois in 1936 as assistant to the manager of the stainless steel division of this U. S. Steel subsidiary, the position he held at the time of his recent appointment.

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TAGS FURNISHED BLANK—COMPLETELY OR PARTIALLY EMBOSSED—IN A WIDE RANGE OF SIZES

TAGS ALSO SUPPLIED IN HUNDREDS OF SHAPES AND SIZES—FOR EVERY IDENTIFICATION PURPOSE

Write for Catalog 146-F Today!

Metal shipping tags speed delivery of products by reducing or eliminating lost shipments due to illegible addressing. They withstand exposure to rain, snow, oil or grease, also, grinding and scraping in piling or handling. Write today for complete data.

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OIL IMMERSED MOTOR CONTROL

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

G. Clymer Brooke has been made assistant to the president, Birdsboro Steel Foundry and Machine Company, Birdsboro, Pennsylvania.

Mr. Brooke has been associated with the company since 1931, starting in the estimating department, and becoming sales representative in 1933, assistant to the vice-president in charge of sales in 1938, and assistant secretary of the company in 1941. Mr. Brooke was educated at St. Paul's School, Concord, New Hampshire, and at Yale University, where he graduated in 1928. He is a member of the Iron and Steel Institute and a director of the E. & G. Brooke Iron Company of Birdsboro, Pennsylvania.

GEORGE S. MICAN

George S. Mican has been made division superintendent of rolling mills in the South Chicago plant of Carnegie-Illinois Steel Corporation, succeeding **Charles C. Hill, Jr.,** who has been transferred to the company's engineering department in Pittsburgh.

Mr. Mican has been serving at South Works since March 1, 1942 as assistant to general superintendent. He started his steel industrial career in 1919 as a machine shop apprentice and progressed steadily through various positions, largely in rolling mills, to his new post. He is a mechanical engineering graduate of the University of Illinois.

Mr. Hill has been at the South Chicago plant since June 2, 1936. He previously had been associated with another U. S. Steel Corporation subsidiary, the American Steel and Wire Company. He, too, began his steel work in 1919 starting as an open hearth clerk in the Donora, Pennsylvania, plant. Later he was transferred to the Worcester, Massachusetts, plant and was with the steel and wire company until 1935 when he became associated with Carnegie-Illinois at the Duquesne Steel Works near Pittsburgh. Mr. Hill is a University of Pittsburgh graduate with a degree of metallurgical engineering. He was an officer in the Army Air Forces in the last World War.

Major Ingvald E. Madsen, U. S. Army, known to readers of the Iron and Steel Engineer through his research work and reports on crane girder design, upon which were based the A. I. S. E. specifications for crane

girder design, was recently awarded the Legion of Merit for perilous reconnaissance work in the China-Burma-India theater of operations.

H. S. Hill, for many years in charge of the Atlanta, Georgia, office of the Trumbull Electric Manufacturing Company, Plainville, Connecticut, has been placed in charge of a new southeastern district office at Atlanta. Associated with him are **E. E. Frost** and **A. T. Allison,** who have been operating out of Nashville and Charlotte, respectively, and **Hugh N. Delinger** in New Orleans.

H. S. HILL

Edgar C. Thomas, recently honorably discharged from the U. S. Army with the rank of major, has been elected vice-president of Thomas Machine Manufacturing Company, Pittsburgh, Pennsylvania.

Mr. Thomas has spent his entire industrial career in the company, founded by his father George P. Thomas, working in many capacities. Prior to the war he had charge of the company's Chicago office and later of its Philadelphia office, handling a large percentage of both domestic and foreign sales.

A member of the U. S. Army Reserve Corps since 1923, he served in the war as batallion commander, anti-aircraft artillery, until returning to the company. As vice-president he will direct sales, working through both Pittsburgh and Philadelphia offices, and with particular emphasis on foreign markets.

William P. Headden has been appointed assistant manager of the sales engineering department of the Standard Oil Company of New Jersey, it was announced today. Since early in 1943, he has been supervisor of the fuels and lubricants section of the division.

A graduate of Rensselaer Polytechnic Institute in 1929, Mr. Headden joined the Standard Oil Company at Bayway, New Jersey, as a student engineer. In 1934, he was moved to 26 Broadway and in 1937 he was promoted to assistant supervisor of the fuels and lubricants sections. Since the outbreak of war he has been devoting much of his time to the solution of lubrication and fuels problems of war industries.

"GOOD TURNS"

for

ROLL NECKS

Use DIXON'S ROLL NECK GRAPHITED GREASE. Benefit by this special made-for-the-purpose lubricant. Do your roll necks a "good turn" by lessening wear at bearing points... preventing undue scoring of necks and brasses. Dixon "freedom-from-friction" saves power as well as machining... saves time and labor and power costs as roll necks need less attention. Particularly recommended for mills equipped with plain bearings. For comprehensive studies in power-saving, ask for RN—

Know-How Packages

FOR DIXON'S GRAPHITES

Use-pictures, instructions and a 7-page booklet on the container show how and where to use graphite profitably.

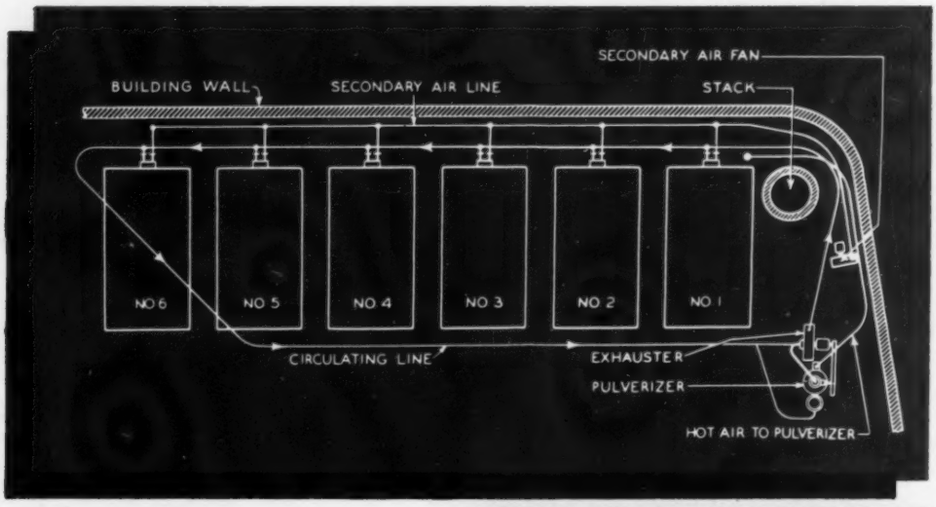
THE KNOW-HOW PACKAGE IS NOW USED FOR THE FOLLOWING GRAPHITES:
1 and 5 pound containers Ticonderoga No. 1 (Large Flakes)
1 and 5 pound containers Ticonderoga No. 2 (Medium Flakes)
1 and 5 pound containers No. 635 (Finely Powdered Flakes)
½, 1 and 5 pound containers Microfyne (Extra Finely Powdered Flakes)
Round all-cardboard containers will replace all-metal containers when stock is exhausted. From your regular supplies, or write for folder 18.

JOSEPH DIXON CRUCIBLE COMPANY, JERSEY CITY 3, N. J.

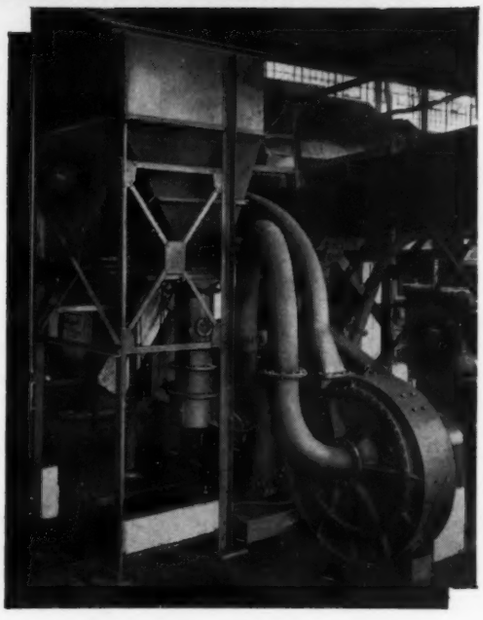
Canada: Canadian Asbestos Company • Montreal • Vancouver • Toronto • Winnipeg

Microfyne Graphite • Pipe Joint Compound • Graphite Seal • Waterproof Graphited Grease
Graphited Oils • Gear Lubricants • Cup and Pressure Gun Grease • Auto-Marine Grease
Graph-Air Guns • Lathe Center Graphite Lubricant • Belt Dressing (Contains no Graphite)

SIX ANNEALING KILNS FIRED WITH PULVERIZED COAL



. . . by a *SINGLE* B&W PULVERIZER



The economical operation of a B&W Direct-Firing Pulverized-Coal Circulating System on five other kilns in the same plant proved the wisdom of firing these SIX kilns also with pulverized coal, using the circulating system.

Only ONE pulverizer is needed with this system because B&W Pulverizers are built to stay on the job and to pulverize their rated capacity in coal to the fineness necessary for the specific purposes.

With the B&W Direct-Firing Circulating System, space is efficiently used and interference with product-handling operations is avoided, since the pulverizer is placed where convenient and the pulverized-coal circulating line is looped overhead around the furnaces served. Complete flexibility in multi-furnace operation is obtained because as many take-offs to burners are provided as may be necessary and the burners may be turned on and off as desired. Kiln temperatures are controlled with the same ease, and by methods similar to those used with gas and oil firing.

For further details on pulverized-coal firing of metallurgical furnaces, write for a copy of B&W Bulletin 3-333.

PM-103

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
85 LIBERTY STREET NEW YORK 6, N. Y.

James L. Fitzsimmons has become affiliated with Electro-Technical Products, Inc., Nutley, New Jersey, in the field of sales promotion in the electrical insulation division of the company. He was previously with the industrial sales division of John C. Dolph Company, Newark, New Jersey.

J. L. FITZSIMMONS

Henry D. Engelsman has been appointed sales manager and technical service supervisor for the Metallizing Company of America, 1330 West Congress Street, Chicago, pioneer manufacturer of Mogul metal spray equipment. Mr. Englesman has been associated with the company for two years as sales and service engineer. Prior to that time he was employed by the DeVilbiss Company as a sales and service engineer.

HENRY D. ENGELSMAN

H. H. Tullis has been elected controller of The American Rolling Mill Company. He had been assistant controller of the company since 1936.

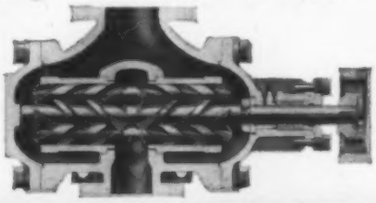
After attending Dennison University, Mr. Tullis became resident manager of the Covington, Kentucky, plant of the Hooven and Allison Company. He joined The American Rolling Mill Company in 1928, spending several years on special assignments in the company's Personal Relations and Controller's Divisions, during which he directed several important studies in the field of personnel research.

The IMO OIL PUMP
Small but Effective

LIKE THE SUBMARINE ON WHICH IT IS USED

The submarine represents the most concentrated power known to naval warfare. Similarly, the IMO oil pump provides great concentration of pumping capacity in small space. It is extremely compact, rugged, simple and reliable, having only three moving parts and no valves or pilot gears.

The IMO oil pump is used on submarines for pumping both fuel and lubricating oils. You can use this small, but effective, pump for handling oil of practically any viscosity, in any volume, and at any pressure. Ask for Leaflet I-112.



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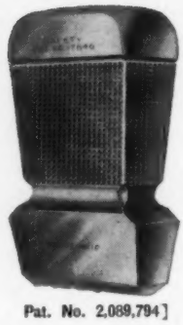
ALL HANDS SAFE!

. . . with the
SAFETY "WEDGE GRIP"
STEEL HAND STAMP

Save manpower hours with Cunningham "Wedge Grips!" Insuring a definite grip . . . in addition to Cunningham **SAFETY** Steel eliminating spalling and mushrooming, they're ideal for mass production of identical markings.



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M.E. CUNNINGHAM CO.
SAFETY STEEL STAMPS
105 EAST CARSON ST., PITTSBURGH, 19, PA.

E. H. Broden, manager of operations of the Pittsburgh district of the American Steel and Wire Company, a subsidiary of U. S. Steel Corporation, has retired after almost half a century of service with the company. Mr. Broden, who relinquished his post June 1, was born in Cleveland, Ohio, in 1877. He has worked for the wire company for 48 years starting his career in 1896 in the machine shop of the old H. P. Works in Cleveland. He worked in various mills of the wire company throughout the country until March, 1906, when he took the position of mechanical engineer at the company's Allentown, Pennsylvania, works. In the years following, Mr. Broden's service had been continually in the Pittsburgh district plants of the wire company. He had held the position of manager of operations of that district since November, 1933.

L. F. McGlincy, former assistant manager of operations of the Pittsburgh district of American Steel and Wire Company, has succeeded Mr. Broden. Mr. McGlincy was born in Worcester, Massachusetts, and attended the public schools in that city before matriculating at Worcester Polytechnic Institute from which he was graduated with a B.S. degree in mechanical engineering. He was first employed by the American Steel and Wire Company in September, 1924, as a rate setter at South Works in Worcester. During the next ten years, he received various promotions and in 1935 became superintendent of the South Works open hearth and rolling mill. In March, 1939, he was transferred to the Cleveland office of the company as assistant metallurgist in charge of billet and rod rolling. He was made general superintendent of Donora Steel and Wire Works at Donora, Pennsylvania, in 1941, and in November, 1943, became assistant manager of operations of the Pittsburgh district under Mr. Broden whose position as manager of operations he now assumes.

W. O. Everling has been appointed director of research of the American Steel and Wire Company, U. S. Steel subsidiary, succeeding J. S. Richards, deceased. **R. H. Barnes** has been named assistant director of research to replace Mr. Everling.

Mr. Everling's first association with the U. S. Steel Corporation was from August, 1927, to November,

N·B·M BRONZE AND COPPER CASTINGS

Blast Furnace Copper Castings • Roll Neck Bearings • Housing Nuts • Machinery Castings • Acid Resisting Castings • Phosphorized Copper • Locomotive and Car Journal Bearings • Babbitt Metals

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1928, when he was a draftsman for the Carnegie Steel Company. In January, 1930, he joined the American Steel and Wire Company as a draftsman at the Newburgh Steel Works and three years later was transferred to a similar position in the Cleveland office. During the period May, 1936, to September, 1940, he was assistant master mechanic and plant engineer at the Cuyahoga Works in Cleveland and in October, 1940, he was appointed assistant director of research of the company.

Mr. Barnes has worked for American Steel and Wire Company since October, 1920, when he was hired as a laboratory assistant at the Newburgh Steel Works. He held various positions at that plant and at the Cuyahoga Works in Cleveland before being transferred to the Cleveland district manager's office in March, 1937, as assistant district metallurgist. In October of the same year, he was made district metallurgist and in February, 1939, he was appointed division metallurgist in the metallurgical department, a post which he has held to the present time.

Obituaries

John B. Tytus, vice-president of The American Rolling Mill Company, died suddenly on June 2nd of a cerebral hemorrhage.

Mr. Tytus was born in Middletown, Ohio, on December 6, 1875, graduated from Yale in 1897, and worked for a time in his father's paper mill in Middletown. In 1902 he joined a contracting firm and spent two years in construction work.

The steel business attracted him, and in 1904 he started to work as a member of an Armco hot mill crew. He soon became a foreman and later was made assistant general superintendent of Armco's original plant. In 1908 he became superintendent of the company's Zanesville, Ohio, plant, returning to Middletown in 1910 as sheet mill superintendent and assistant general superintendent of the East Works plant.

Beginning in 1913, he conducted a series of experiments which proved conclusively that it was possible

JOHN B. TYTUS

to roll iron and steel sheets continuously. In 1922, The American Rolling Mill Company sent Mr. Tytus to Ashland, Kentucky, to supervise the designing, construction, and operation of the world's first continuous sheet rolling mill.

For his part in this development, the American Iron and Steel Institute presented Mr. Tytus with the Gary Medal "for distinguished service to the progress of the industry" in 1935. The National Association of Manufacturers presented him with the Modern Pioneer Award for the same development in 1940. He was elected a vice-president of Armco in 1927 and became vice-president in charge of technical development in 1943.

ASSOCIATION OF IRON AND STEEL ENGINEERS

Annual Engineering Conference

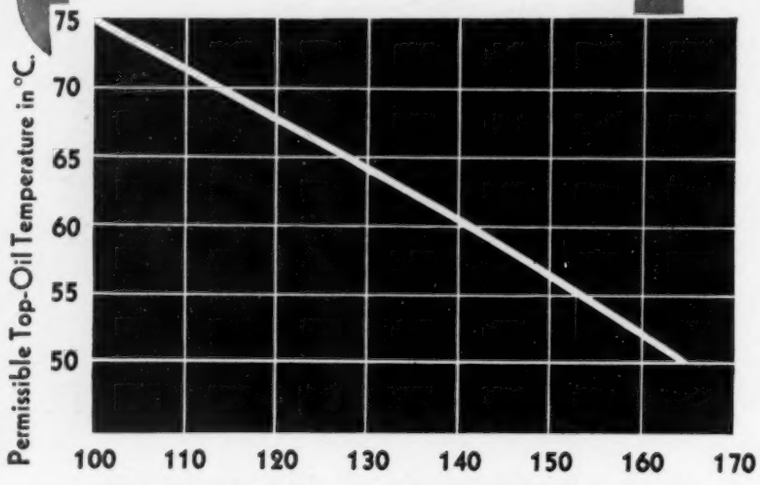
MONDAY, TUESDAY and WEDNESDAY
SEPTEMBER 25 - 26 - 27, 1944

WILLIAM PENN HOTEL PITTSBURGH, PENNSYLVANIA

SIMPLIFIED REFERENCE TABLE TO HELP ANY OPERATOR

OVERLOAD

PENNSYLVANIA POWER TRANSFORMERS



20,000 kva, 25-cycles, OISC, outdoor, three phase, rated 4400-6600 volts, with forced air cooling equipment to permit increased capacity of 26667 kva without exceeding temperature rise of 55°C.

HOW TO USE OVERLOAD TEMPERATURE CURVE

With any continuous load shown on the curve, the corresponding top oil temperature must not be exceeded.

EXAMPLE: If a transformer, while carrying 100% load, is found to have a top oil temperature of 75°C., and it is desired to carry 30% overload on this transformer, additional cooling must be provided to bring the top oil temperature down to 64°C. when the transformer is carrying 130% load.

It is not always necessary to provide additional cooling in order to obtain additional capacity. Low ambient temperature, low load factor, and similar conditions will permit the transformer to be overloaded to the extent shown on the curve, as long as the corresponding permissible oil temperatures are not exceeded.

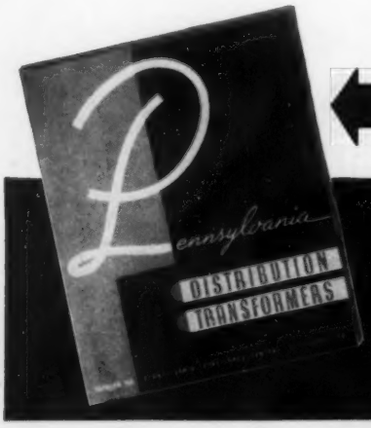
ADDITION OF FORCED COOLING

Increased rating may be obtained economically by the addition of forced-air-cooling, fans, or forced-oil-cooling units. For information as to type, number, and size of fans and cooling units, you are invited to consult our Engineering Department.

LIMITATIONS

The above guide applies to Pennsylvania Power Transformers which have been properly operated and maintained. The oil must be in good condition as indicated by dielectric strength and color. Samples of oil may be sent to our factory where they will be tested without charge.

Before applying overloads to transformers, a careful check should be made of the thermal capability of all associated equipment, such as circuit breakers, switches, current transformers, cables, meters and relays. Before exceeding 135% load on any transformer, it is recommended that advice be obtained from our Engineering Department as to any limitations involved, such as oil expansion, pressure in sealed-type units, bushing ratings, etc.



Standard transformers available in sizes up to 150 Kva.

Write for our catalog No. 142 on Distribution Transformers.

Pennsylvania
TRANSFORMER COMPANY
PITTSBURGH, PENNSYLVANIA

Pennsylvania TRANSFORMERS

Typical motorized hand lift truck

GIVE YOUR
MOTORIZED HAND-LIFT TRUCKS THIS

10% EXTRA WORK CAPACITY

WITHOUT INCREASE IN BATTERY BOX DIMENSIONS

WHEN materials pile up, that's when the 10% extra capacity built into Philco XL Batteries can be a life-saver!

In this ultra-modern storage battery designed by Philco, you'll find the extra reserve of power you need to keep your trucks on the job longer hours—to deliver the extra wallop when needed—to haul more material each day.

Let us show you how Philco XL extra capacity Batteries today are solving the materials handling problems at crowded war plants, warehouses and ports of embarkation. Write for Industrial Truck Battery catalog. See directory for local Philco representative.

PHILCO CORPORATION
STORAGE BATTERY DIVISION, TRENTON 7, N. J.

Specify

PHILCO

INDUSTRIAL BATTERIES

Stop Oil Showers From Crane Motors

Constant oil leakage from overhead crane motors results in high oil and application cost. Bearings must be filled frequently to insure protection from failure.

Drippage causes other heavy losses. Tracks and pillars must be cleaned to lessen fire hazard. Stock cleaning costs are increased when oil deposits must be removed.

NON-FLUID OIL stops such losses. Saves money because it does not drip or leak. You get clean lubrication and clean steel at lower cost.

NON-FLUID OIL is being used successfully in leading iron and steel mills. Send for instructive bulletin.

•

New York & New Jersey Lubricant Co.

Main Office: 292 Madison Ave., New York 17, N. Y.

WAREHOUSES:

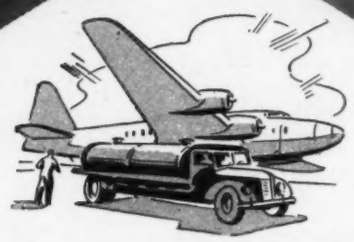
Chicago, Ill. — Atlanta, Ga.
St. Louis, Mo. — Detroit, Mich.
Providence, R. I. — Charlotte, N. C. — Greenville, S. C.

TRADE MARK REGISTERED
NON-FLUID OIL
IN U.S. PAT OFFICE & FOREIGN COUNTRIES

Modern Steel Mill Lubricant

Better Lubrication at Less Cost per Month

MORGANITE BRUSHES



When a machine constructor chooses a grade of brush for a given motor or generator, he wants to know that the material is uniform and can be uniformly reproduced over a period of years.

In service also, operating and maintenance men want brushes that give identical results when replacements are required.

Through the years, Morganite brushes have remained uniform within close limits. Because constructors and operators know they can depend on Morganite brushes, you will find them on many heavy duty machines.

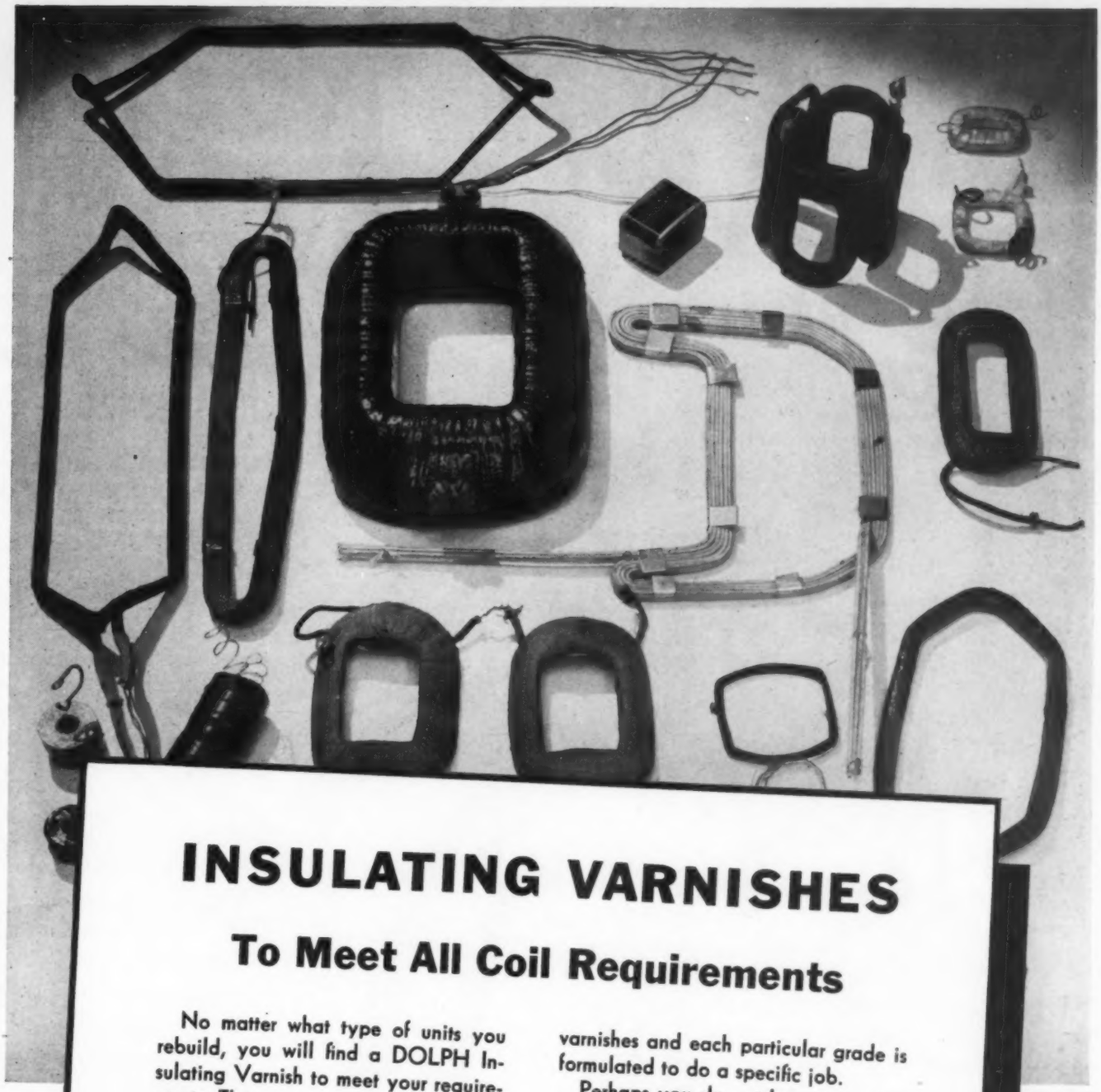
When a brush problem arises, communicate with Morganite and obtain an honest helpful answer.

MORGANITE BRUSH COMPANY, Inc.
Long Island City 1, New York

TRADE MARK

No. 5 In a Series of Factors Essential to Maximum Brush Efficiency

. . . uniformity of material necessary for continued brush satisfaction



INSULATING VARNISHES

To Meet All Coil Requirements

No matter what type of units you rebuild, you will find a DOLPH Insulating Varnish to meet your requirements. The reason is this — For over a third of a century, we have specialized only in the manufacture of electrical insulating varnishes and compounds. Through our vast experience, we have developed several hundred different varnishes and each particular grade is formulated to do a specific job.

Perhaps you do not know just what type of varnish to specify for treatment of your coils. As we maintain a fully equipped laboratory, we are confident no matter what your problem may be, we can help you. There is no obligation, so why not let us assist you?

Dolph's

JOHN C. DOLPH COMPANY

Insulating Varnish Specialists

166 EMMETT STREET NEWARK 5, NEW JERSEY

OHIO

Maximum Lift MAGNETS

A standard 65" Ohio Magnet
Lifting 5200 lbs. of Pig Iron

Standard round general purpose Ohio magnets are built in sizes from 12" to 65" in diameter.

Average lifting capacity for pig iron or scrap ranges from 200 lbs. to 6200 lbs.

Depending upon the amount of material to be handled, the largest suitable magnet will do it most economically.

Labor cost per lift is the same whether the lift be 200 lbs. or 6200 lbs.

THE OHIO ELECTRIC MFG. COMPANY

5907 Maurice Ave. Cleveland, Ohio

NATIONAL ROLLS

STEEL PRODUCTION OF TOMORROW

NEVER before in world history will the demand for all kinds of materials and goods be more pronounced than with the advent of peace.

European devastation has so far been mere newspaper words to most of us. We have not seen what cannot be adequately described — the scrambled railroads, plants, buildings, wharves and ships left in the wake of bombs.

Steel will be one of the chief materials of reconstruction.

And steel is largely dependent on good rolls.

The makers of NATIONAL ROLLS have kept abreast of every metallurgical improvement in roll making, inspired by the war emergency, and look forward with optimism to the greatest era of American steel production that our nation has ever experienced.

The NATIONAL ROLL & FOUNDRY COMPANY

All Grades of Cast Rolls—Iron and Iron Alloy—Steel and Steel Alloy
Heavy Iron Castings and Rolling Mill Equipment

AVONMORE, PA.

IS YOUR PROBLEM ONE OF *Speeding Carloading or Unloading?*

Industrial Trucks have revolutionized carloading and unloading methods. Our files contain hundreds of case histories in which Baker Trucks have reduced time, cost and manpower on these operations to a fraction of former requirements. A few typical installations are described below.

★ ★ ★

Baker Low Lift Trucks load and unload forged parts, castings and other materials on skids—eliminating individual handling of pieces. In many cases shipment is made on skids, enabling trucks to also save time at receiving end. Illustration shows skid-load of zinc pigs being loaded into a box car.

Equipped with telescoping uprights a Baker Hy-Lift Truck can enter a box-car door with ease, and tier material inside the car, conserving shipping space. (See illustration). Actual savings in costs of loading and unloading operations with Baker Trucks have been reported as high as 75% over former methods.

Where material lends itself to shipment on wooden pallets, Baker Fork Trucks can greatly reduce time and cost of loading and unloading. One Company reports savings of 25c per ton, or $12.50 per car—at the same time releasing seven men for other work. This procedure is called "Unit Handling."•

Baker Crane Trucks have solved many difficult loading problems, where heavy, bulky parts or materials are to be shipped on gondola or flat cars. Illustration shows a crane truck with a large hook making quick work of loading heavy coils of wire at a wire mill.

A large aircraft manufacturer uses Baker Hy-Lift Trucks to unload crated airplane engines weighing 2100 pounds from the boxcar in which they are shipped. One operator with a truck transports the engines either to storage, or to the assembly line—relieving a number of men for other duties.

Highway-truck loading with Baker Fork or Hy-Lift Truck requires no loading platform. Sacks of bulk materials may be handled or shipped on pallets, eliminating the need for individual handling, and permitting tiering of material in warehouse or carrier.

• A bulletin "Unit Loads—Their Handling, Shipment and Storage" has just been published by the Industrial Truck Statistical Association. A copy will be mailed upon request.

If you have a material handling problem and are looking for the best answer, your nearest Baker Material Handling Engineer will gladly help you.

BAKER INDUSTRIAL TRUCK DIVISION *of The Baker-Raulang Company*

2166 West 25th Street • Cleveland, Ohio

In Canada: Railway and Power Engineering Corporation, Ltd.

LOOK AT THESE BAKER CONSTRUCTION FEATURES BEFORE YOU BUY AN INDUSTRIAL TRUCK

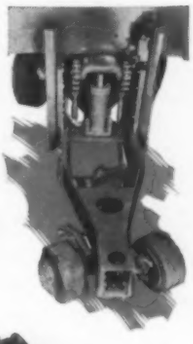
Every part of every Baker Truck has been especially designed for its specific function. Many Baker features are exclusive, others, pioneered by Baker, are now standard in the industry.

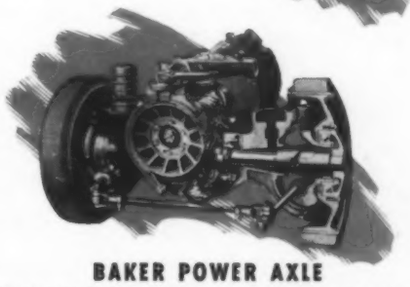
BAKER DUPLEX COMPENSATING SUSPENSION

All wear due to sliding action between axle and frame is eliminated by two wishbone yokes, which hold the power axle in alignment. One yoke resists driving torque, the other driving and brake thrust. Thus the axle is accommodated freely to rough floor conditions, and no twisting strain is transmitted to frame or steering rods. Starting and stopping jars are reduced, and time out for repair is minimized.

BAKER HYDRAULIC LIFT

Efficient, trouble-free hydraulic lift provides power lifting and gravity lowering under absolute control at all times. Motor-driven gear pump supplies oil under pressure to cylinders with speed controlled by metering valves. Movement of hydraulic jack is compounded through a pair of chains and sprockets.





BAKER POWER AXLE

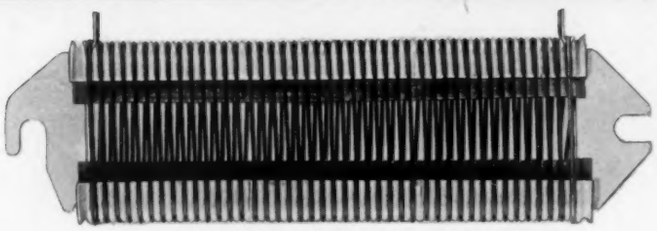
Exclusive Baker design provides most efficient operation, low maintenance and long life. Hardened alloy steels are used in all vital parts. All bearings, axle shafts, and universal joints are dust protected.

WRITE FOR YOUR COPY

Plant and production managers, traffic managers, superintendents, purchasing agents and any others concerned with material handling will find the new Baker Catalog No. 52 a valuable reference.

Baker INDUSTRIAL TRUCKS

"3C" VENTWOUND RESISTORS



CLOSEUP VIEW OF VENTWOUND UNIT

For use with smaller A. C. and D. C. Motor Drives, or as field and discharge circuits where units of this size can be used, or where negligible resistance change, due to temperature variation, is essential, "3C" Bulletin 113 Ventwound Resistors fulfill the requirements in many applications.

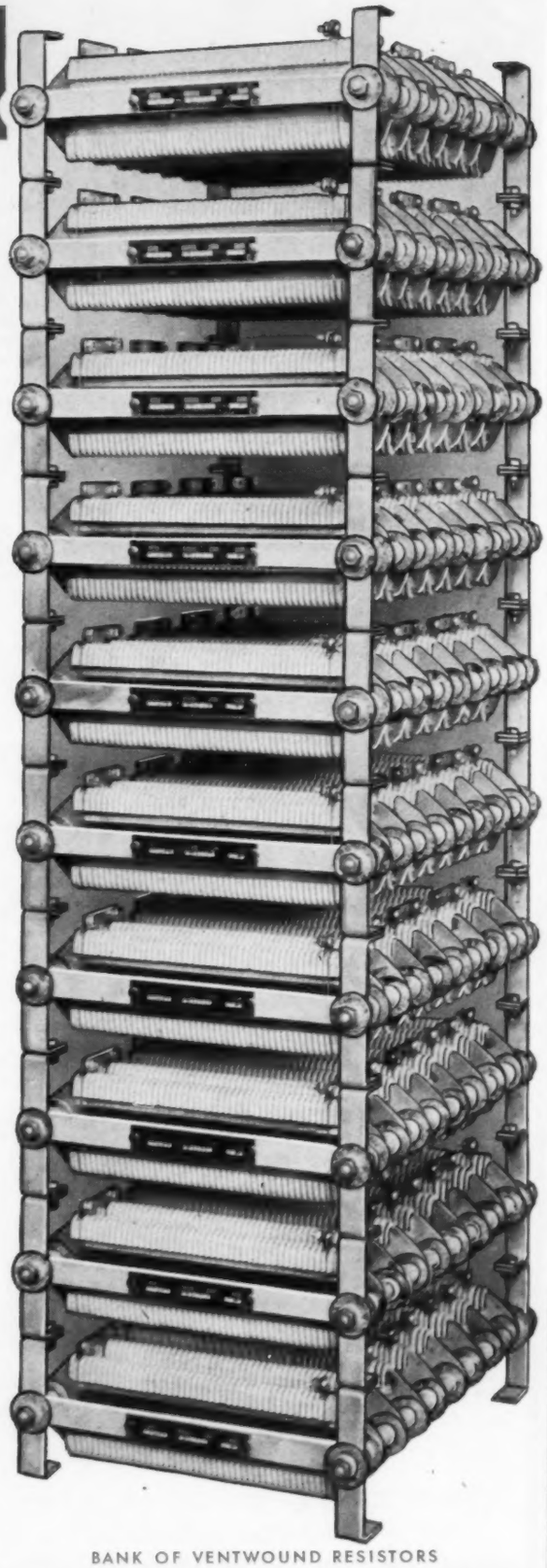
FEATURES

1. NON-BREAKABLE
2. CORROSION RESISTANT
3. RESISTANCE CONSTANT REGARDLESS OF TEMPERATURE
4. FLEXIBLE ASSEMBLY
5. TAP CONNECTIONS AVAILABLE
6. DOUBLE INSULATION TO GROUND
7. NON-IMBEDDED RESISTOR MATERIAL
8. EFFECTIVE HEAT DISSIPATION BY UNRESTRICTED AIR CIRCULATION

Ventwound Units have full length cadmium plated steel cores, and sectional Porcelain Insulators grooved to hold individual turns of resistor wire. A relatively large window is provided to give unrestricted air circulation.

The resistor wire has a negligible temperature co-efficient of resistance—a qualification of particular advantage either in motor field circuits or on regulating resistance, where a change in resistance due to resistor heating causes motor speed change.

Ask for fully descriptive "3C" Bulletin 113.

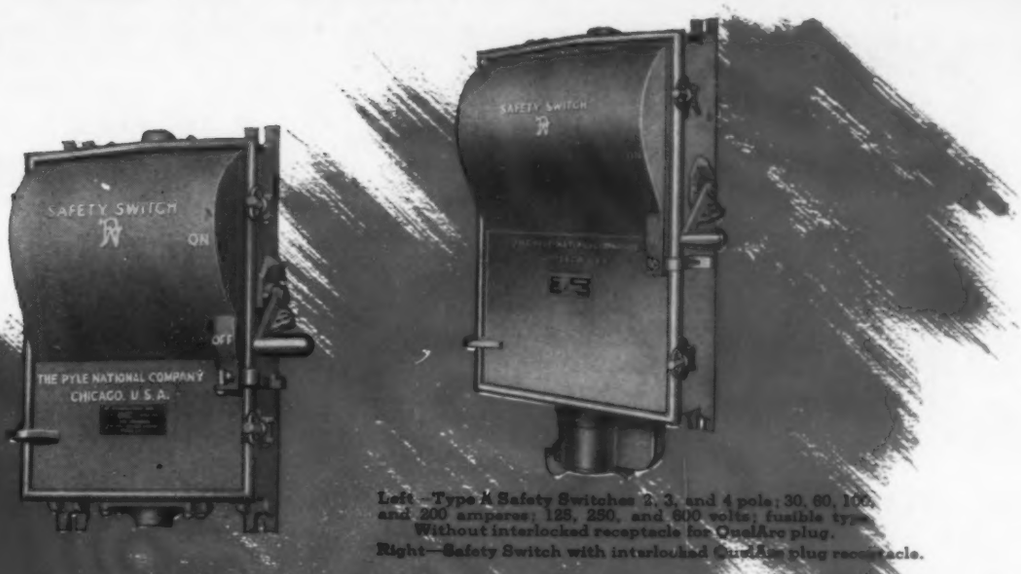


BANK OF VENTWOUND RESISTORS

CONTINUE TO ROLL WITH CLARK CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152ND ST. CLEVELAND, 10, OHIO



Left—Type A Safety Switches 2, 3, and 4 pole; 30, 60, 100, and 200 amperes; 125, 250, and 600 volts; fusible type. Without interlocked receptacle for QuelArc plug.
Right—Safety Switch with interlocked QuelArc plug receptacle.

Heavy-Duty Safety Switches and Circuit Breaker Pylets

BUILT FOR MILL AND RAILROAD SERVICE

Circuit breaker Pylet with interlocked receptacle and QuelArc plug.

Pyle-National safety switches have the substantial construction needed to withstand severe operating conditions. The case and cover are heavy-section galvanized cast iron; operating parts are of heavy cast metal, and are designed for quick make and break action. Contacts are mounted on heavy slate. The operating shaft has bronze bearings. The case is fully protected, with both cover and hub plates equipped with weatherproof gaskets. The operating lever extends through the case in a rustproof bearing, and the cover is held closed by rustproof wing nuts and bolts. These features assure dependable service and long life even under severe operating conditions.

Circuit breaker Pylets are of similar heavy duty construction, and are available with or without interlocking receptacle for QuelArc plugs.

Write for Pylet general Catalog 1100 with complete listings.

PYLE-NATIONAL
ELECTRICAL EQUIPMENT
• SINCE 1897 •

THE PYLE-NATIONAL COMPANY
1334-58 North Kostner Avenue
Chicago 51, Illinois

Offices: New York, Baltimore, Pittsburgh, St. Louis, St. Paul, San Francisco

CONDUIT FITTINGS • FLOODLIGHT PROJECTORS

LOCOMOTIVE ELECTRICAL EQUIPMENT

Sound the Alert!

MANAGEMENT
LABOR

—for the 5th War Loan drive during June and July. The need for the 5th War Loan is immediate, crucial. For impending events may make the 5th the supreme financial effort of the war.

The U. S. Treasury has set the overall goal at $16,000,000,000 — $6,000,000,000 from individuals alone. This is the biggest sum ever asked of the American people—*and it must be raised.*

That's why the U. S. Treasury asks Management and Labor to sit down together and organize—NOW!

For organization—good organization—has been responsible for the excellent showing of the payroll market. And its most important single superiority has been personal solicitation—desk to desk, bench to bench, machine to machine personal solicitation. 71% of all persons on payroll deductions were solicited for the 4th War Loan.

Now, to personal solicitation, add the sales incentive of a definitely established plant quota. Build your campaign around a quota plan. Set up departmental goals. Stress percentage of participation figures. Stimulate group enthusiasm.

In planning your quota campaign, work in close cooperation with the Chairman of your War Finance Committee. Everything is set to make the 5th War Loan drive a huge success—with your help!

(Note: You've read this message. If it doesn't apply to you please see that it reaches the *one* person who can put it in action!)

Here's the Quota Plan:

1. Plant quotas are to be established on the basis of an *average* $100 *cash* (not maturity value) purchase per employee.
2. Regular Payroll Savings deductions made during the drive accounting period will be credited toward the plant quota.
3. 90% of the employees are expected to contribute toward raising the cash quota by buying extra 5th War Loan Bonds: 1—Outright by cash. 2—By extra installment deductions. 3—By extra installment deductions plus cash.

Example: **JOHN DOE Mfg. Co.** — 1,000 Employees

1,000 employees x $100 Regular Payroll deductions during the eight weekly payroll Accounting Periods of June and July = $100,000 Cash Quota

30,000
$70,000 (to be raised by sales of extra Bonds to at least 900 employees)

ORGANIZE • SOLICIT • DELIVER

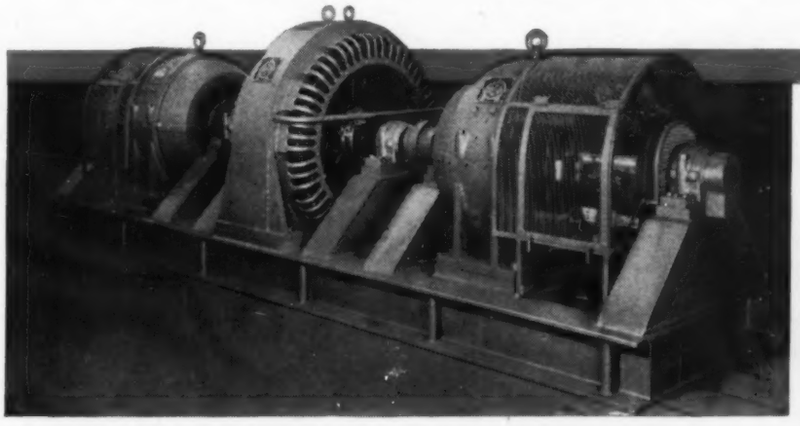
5TH WAR LOAN

The Treasury Department acknowledges with appreciation the publication of this message by

RELIANCE BUILDS WITH STEEL!

FOR STRENGTH *AND* SPEED

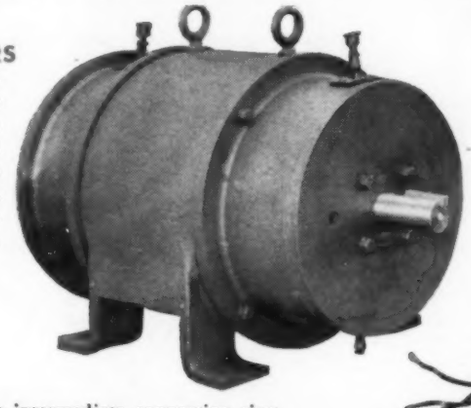
To meet the super stresses and strains to which motors are subjected today . . . the shock test of battle on our Navy's ships . . . new and hard usage on landing craft . . . twenty-four hour a day service in more and more industries . . . and with speed of delivery a factor of vital importance . . . Reliance Motors normally make use of rolled and bar steel.



MOTOR-GENERATOR SET Structural shapes and steel plates, electrically welded, provide the substantial base and pedestals so essential for maintaining correct alignment of this Reliance Motor-generator Set. Manufacturing is facilitated by eliminating patterns, castings and machine work. Set has anti-friction bearings and consists of two 150 kw., 125 volt, d-c. generators with 450 hp. synchronous motor.

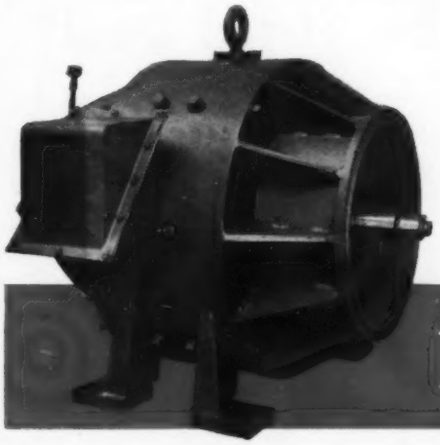
100 HP. PUMP MOTOR The strength and rigidity essential for the "horse-shoe" base of this 100 hp., d-c., vertical Reliance Motor, used for the main circulating pump on Victory Ships—plus the speedy delivery essential to the Victory Ship program—are provided through the use of parts constructed from steel plate, electrically welded.

LANDING CRAFT MOTORS Specifications for this splash-proof, special-torque Reliance Squirrel-cage Motor, to operate a bow-ramp winch, called for steel bearing plates. Delivery to meet the hurry-up call for landing craft was speeded by production of weldments from steel plate and bars.



The biggest 24-hour ventilating job in history has been handled by the space-saving and efficient co-axial fan. To equip our fighting ships, transports and cargo vessels has required thousands of specially-designed steel constructed motors in a hurry. Weldments of steel plate and bar stock for back-bearing brackets helped to get parts through on time.

DIESEL GENERATOR The intermediate connecting ring of this 25 kw., d-c. Reliance Generator for direct connection to a Diesel engine must carry part of the engine weight. It is constructed of steel plate, electrically welded.



RELIANCE ELECTRIC & ENGINEERING CO.

1088 Ivanhoe Road • Cleveland, Ohio

Birmingham • Boston • Buffalo • Chicago • Cincinnati • Detroit • Greenville (S. C.) • Houston
Los Angeles • Minneapolis • New York • Philadelphia • Pittsburgh • Portland (Ore.) • St. Louis
Salt Lake City • San Francisco • Syracuse • Washington, D. C. • and other principal cities.

RELIANCE A-C D-C MOTORS

"UNIVAN"

That Tough Steel

Tough as ever at the Final Bell"

It was a tough fight, and the winner absorbed a lot of punishment, but he had those same staying qualities for which "UNIVAN" castings are noted—ability to withstand heavy shocks and severe stresses with remarkable resistance to fatigue ... Union's scientific heat treatment of a special, fine grained Alloy Steel results in castings which may be specified for chronic "trouble spots" with absolute confidence. Glad to estimate to your exact specifications.

ARMY E NAVY

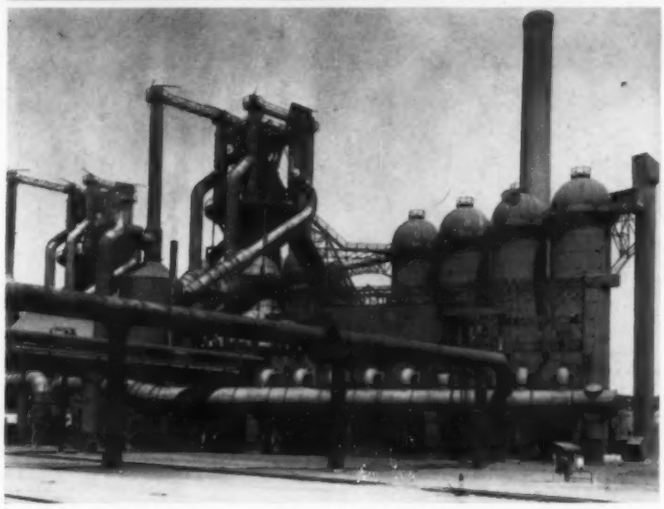
For Long Life with Economy Specify "UNIVAN"-That Tough Steel

BUY MORE WAR BONDS AND STAMPS

UNION STEEL CASTINGS

DIVISION OF BLAW-KNOX CO. PITTSBURGH, PA.

MAKERS OF Driving Wheel Centers, Locomotive Frames, Pump Casings, Vault Doors and Frames, Annealing Boxes, Spindles, Coupling Boxes, Open Hearth Charging Boxes, Gear Blanks — and other Castings for Steel Mills and General Industry.



CLEAN GAS MAINS

INSURE UNHINDERED
OPERATION
AND
MAXIMUM PRODUCTION

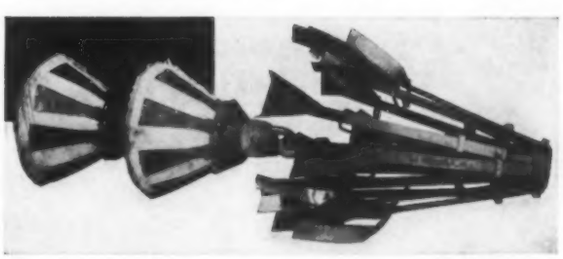
AND GAS MAINS ARE BEING CLEANED BY OUR CONTRACT CLEANING SERVICE

THE TOOL:

Steel plows shear away the sludge and leave a smooth surface. Water passing through cleaner forces dirt out ahead.

THE METHOD:

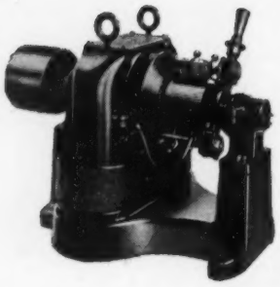
Cleaner is forced through the pipe hydraulically in sizes up to 30 inches. Larger mains are cleaned by dragging the cleaner and flushing with water.



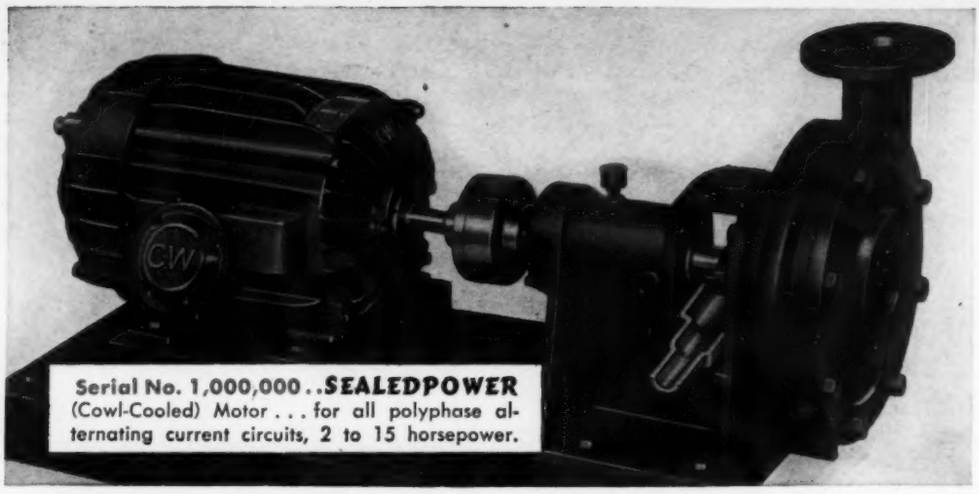
PITTSBURGH PIPE CLEANER COMPANY

433 MELWOOD STREET **PITTSBURGH, PA.**

New York - Philadelphia - Washington - Baltimore - Chicago - St. Louis - Detroit



Serial No. 1 . . . Crocker-Wheeler Motor, built in 1888.

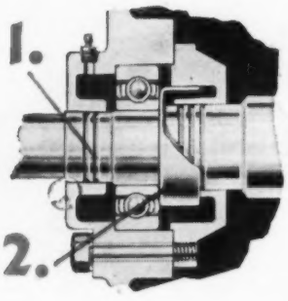


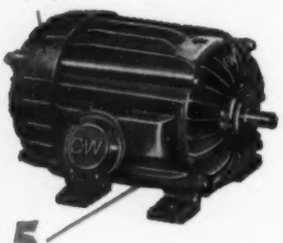
Serial No. 1,000,000..**SEALEDPOWER** (Cowl-Cooled) Motor . . . for all polyphase alternating current circuits, 2 to 15 horsepower.

SEALEDPOWER

Industry's Most Trouble-Free Motor

PRODUCED BY CROCKER-WHEELER'S 56 YEARS OF EXPERIENCE





CROCKER-WHEELER FEATURES:

1. Patented "Groovseal"—no greasing needed for at least a year. Grooves minimize grease loss. This seal makes bearing maintenance expense negligible. It permits use of softer grease, for better lubrication and longer bearing life. Airtight seal prevents dust or other foreign matter from entering bearings.

2. Crocker-Wheeler's exclusive De-Sludging Impeller. Automatically desludges . . . churns and distributes grease to bearings when motor is started.

3. Vacuum Impregnation—standard on *all* Crocker-Wheeler motors. Seals out foreign matter and moisture from each individual coil . . . fills all interstices, making windings a homogeneous mass . . . reduces hot-spot temperature and lengthens insulation life. Adherence of varnish prevents vibration of wires either inside or outside of slot. (Photograph shows cross sections of baseballs, (left) after vacuum impregnation and (right) before vacuum impregnation. Note penetration of varnish to center of tightly-wound ball, making it a moisture-proof, homogeneous mass.)

SEALEDPOWER FEATURES:

4. Totally Enclosed Cowl-Cooled Construction resists corrosion. Protects against acid or alkali fumes, splashing or dripping liquids, air-borne moisture, steam, corrosive gases, conducting dusts, metallic chips, etc.

5. Fin Type Construction for non-clog ventilation and easy cleaning.

WRITE FOR LITERATURE ON THE **SEALEDPOWER** MOTOR, WHICH IS WINNING THE PREFERENCE OF MACHINERY MANUFACTURERS AS WELL AS OF MOTOR USERS. OR CALL OUR NEAREST OFFICE.

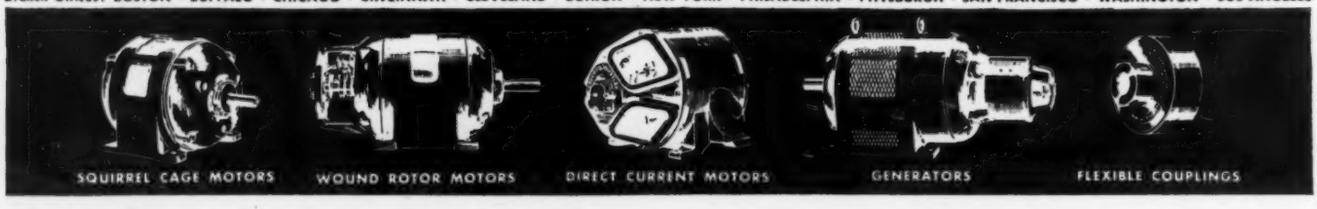
JOSHUA HENDY IRON WORKS

CROCKER-WHEELER DIVISION

ESTABLISHED 1856

AMPERE, NEW JERSEY

Branch Offices: BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DETROIT • NEW YORK • PHILADELPHIA • PITTSBURGH • SAN FRANCISCO • WASHINGTON • LOS ANGELES



NEW MEMBERS

Active

Fred J. Beckmann
Chief Roll Designer
Bethlehem Steel Company
Bethlehem, Pennsylvania

John V. Boardman
General Foreman No. 13 Mill and Beam Yard
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania

Francisco Nelson Chaves
Engineer
Brazilian Steel Works Company
Cleveland, Ohio

William Ross Elliott
General Foreman Spike and Chain Dept.
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania

David Miller Gallmeyer
Electrical Draftsman
The American Rolling Mill Company
Butler, Pennsylvania

R. B. Heilman
Junior Engineering Draftsman
The American Rolling Mill Company
Butler, Pennsylvania

Jerome J. Hein
Assistant Superintendent Roll Department
Inland Steel Company
East Chicago, Indiana

George Herbert
Line Foreman
Wheeling Steel Corporation
Steubenville, Ohio

T. J. Hoffman
Superintendent Electrical Construction
The Steel and Tube Division
The Timken Roller Bearing Company
Canton, Ohio

Frank J. Hovorka
Project Engineer
Carnegie-Illinois Steel Corporation
Duquesne, Pennsylvania

Joseph M. Jeffries
Assistant Master Mechanic Rolling Mills
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania

Hazen J. Leaver
Master Mechanic — Wire Works and Shops
American Steel and Wire Company
Donora, Pennsylvania

Walter R. Ludwig
Superintendent of Rolls
Sheffield Steel Corporation of Texas
Houston, Texas

R. J. MacKenzie
Head Construction Purchasing Bureau
Carnegie-Illinois Steel Corporation
Pittsburgh, Pennsylvania

John F. Maloney
Assistant Chief Electrician
Superior Steel Corporation
Carnegie, Pennsylvania

Thomas McCulloch, Jr.
Master Mechanic
American Steel and Wire Company
Donora, Pennsylvania

James L. McHugh
General Foreman No. 18 Mill
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania

P. E. Nestor
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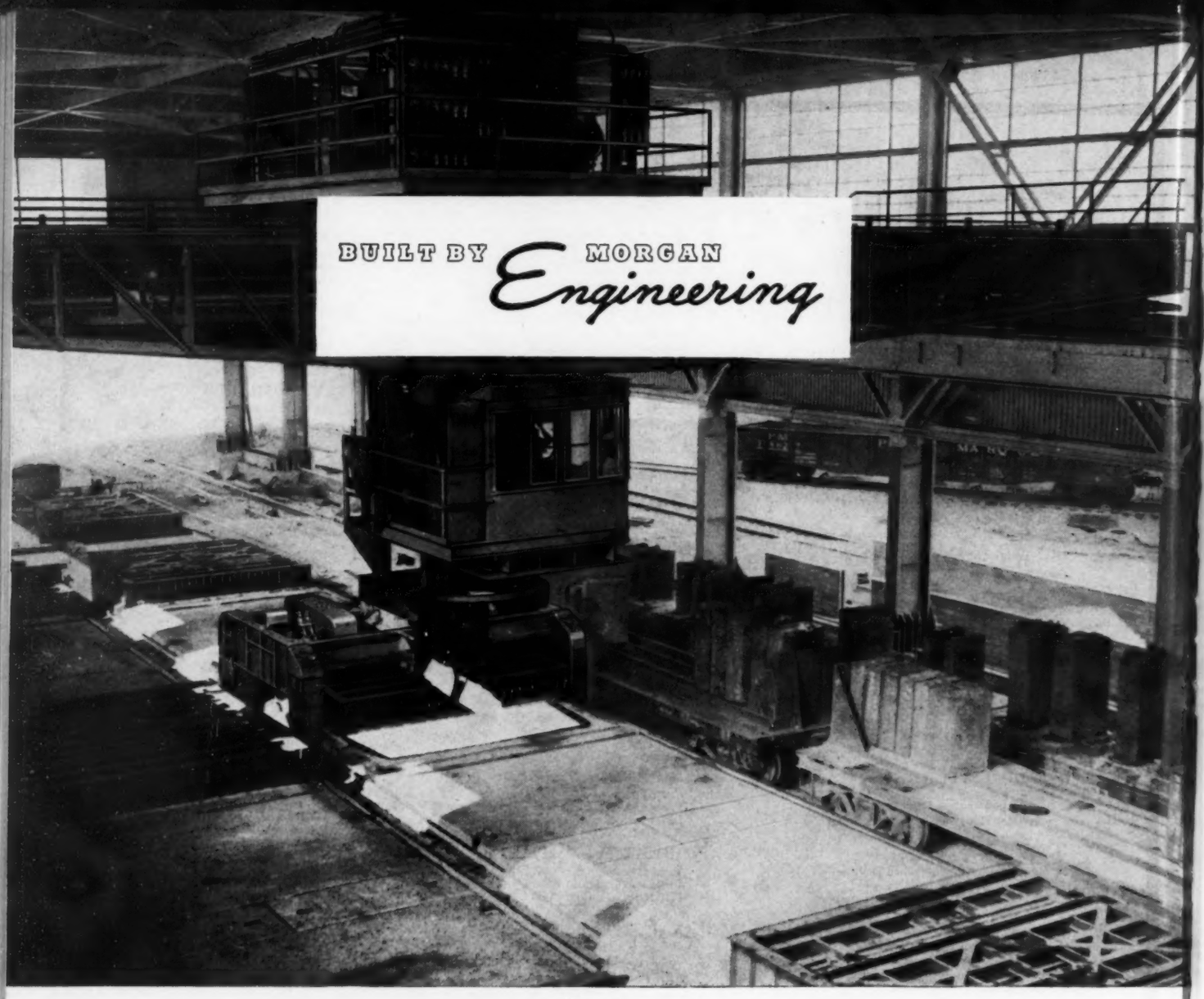

MORGAN 10-TON SOAKING PIT CRANE

HANDLING SLAB INGOTS IN A WEST COAST STEEL PLANT

Illustrated is a Morgan 10-Ton, 7-Motor, 81′ 0″ Span Soaking Pit Crane with 15-Ton Auxiliary Hoist. Morgan superiority of design and construction is built into every part to insure many years of profitable service. It is equipped with fabricated welded trolley and bridge trucks and anti-friction bearings throughout. Trolley is of the worm operated type which simplifies the construction and lowers the cost of maintenance.

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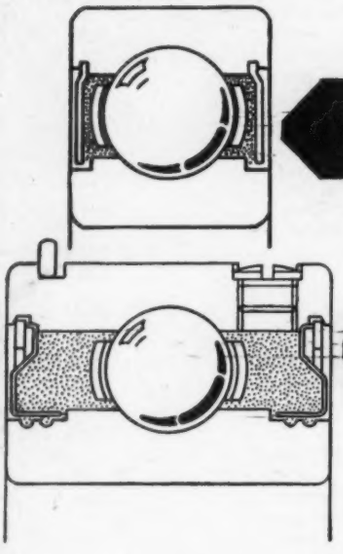
YOU CAN'T GET A QUART INTO A PINT MEASURE



And, "by the same token," you can't get as much grease into a single-row-width "sealed" ball bearing, as goes into the double-row-width "CARTRIDGE" BALL BEARING of equal bore and outside diameter. Look at the section drawings herewith, and you'll see why.

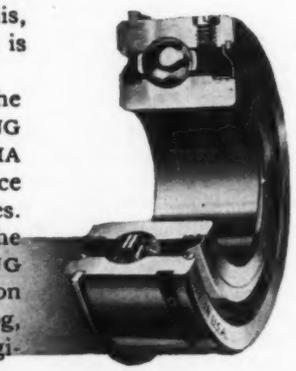
In the single-row-width shielded or "sealed" bearing, see that very small grease space inside the sealing plates. Note further that there is no space available for a highly-efficient, truly grease-tight seal.

Now, in contrast, see that big grease reservoir between the seals, in the "CARTRIDGE" BEARING section—providing at least DOUBLE THE GREASE CAPACITY of the shielded or "sealed" bearing, and greatly extending the greasing intervals. Note, too, how the wide, inwardly-extending seal flanges, and the oil grooves on the inner ring, provide AN IDEAL SEAL THAT PREVENTS THE ESCAPE OF GREASE AND EXCLUDES DIRT, whatever the shaft angle.

Furthermore, the "CARTRIDGE" SEALS ARE REMOVABLE AND REPLACEABLE, should you wish to inspect the bearing or change the grease. And the refilling plug makes it easy to put in a new charge of grease. You can't do this, with the ordinary shielded or "sealed" bearing, which is permanently sealed.

QUALITY, too, is just as vital as QUANTITY, in the grease in your bearings. So, every "CARTRIDGE" BEARING leaves our factory, abundantly packed with NORMA "STABILITY-TESTED" GREASE, which has great resistance to oxidation as well as excellent lubricating properties.

Summing up . . . all these distinctive features of the NORMA-HOFFMANN "CARTRIDGE" BALL BEARING mean prolonged bearing life, less lubrication attention and lower maintenance cost. Write for the Catalog, enumerating many additional advantages. Let our engineers work with you.



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BALL BEARING

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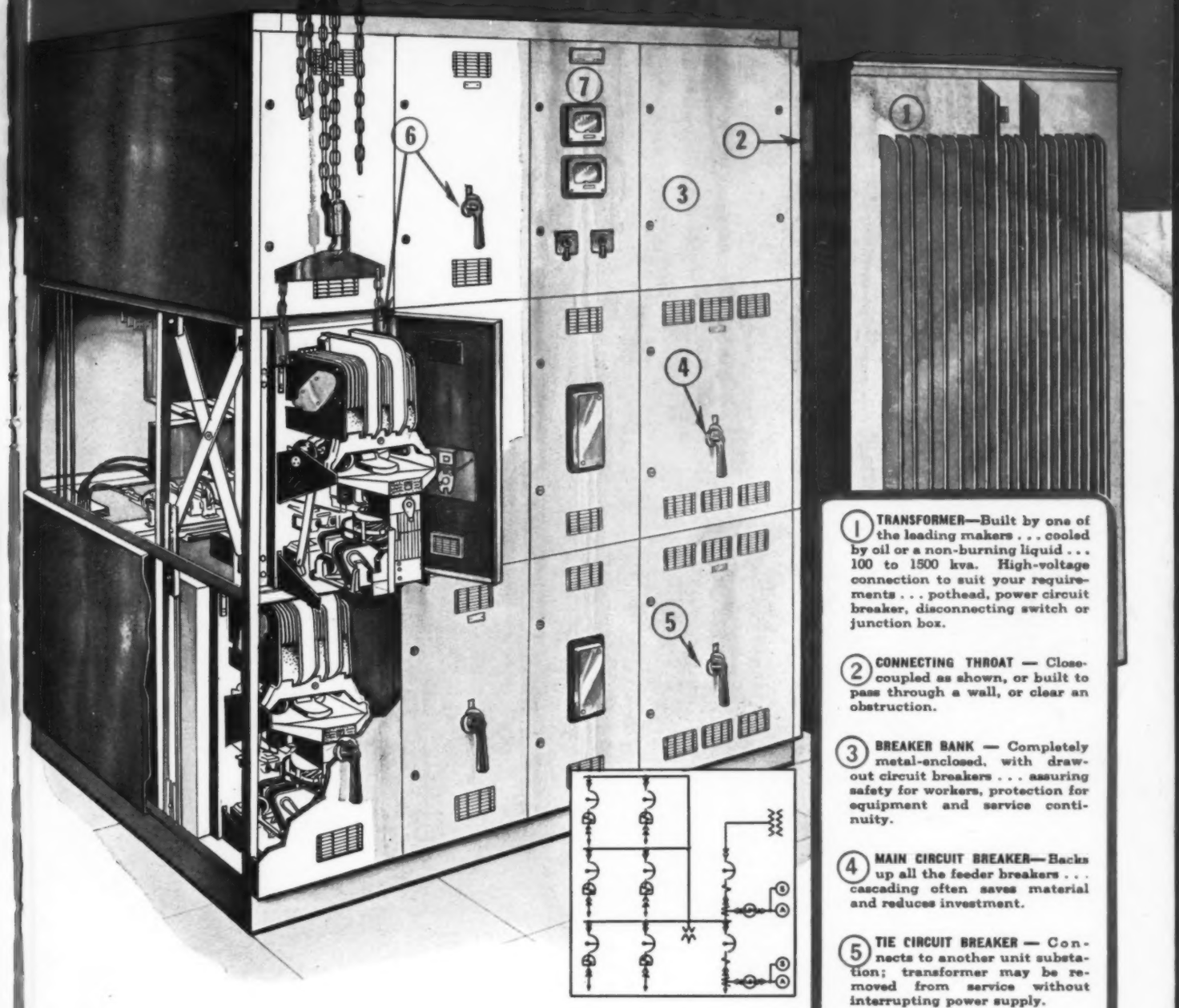
Features You Want in Unit Substations Are Found in I-T-E Steel-Clad Switchgear



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(7) **BUS TRANSITION FRAME** — Provides for branching buses . . . instruments may be mounted on doors.

Advantages of Unit Substations have led to rapid adoption and will lead to much wider use—saving in cable copper, reducing voltage drop by employing short feeders, saving in space with compact arrangement of indoor transformers and breaker banks, quick installation and equally simple removal to a new location.

Design and construction of the unit are important in providing such advantages in fullest measure . . . and "fullest measure" is what steel-mill engineers must have.

The features of design and construction identified on this page are but a few that I-T-E engineers will gladly go over with you. For complete information, get in touch with the I-T-E representative nearest you, or write I-T-E Circuit Breaker Company, 19th and Hamilton Streets, Philadelphia 30, Pa.

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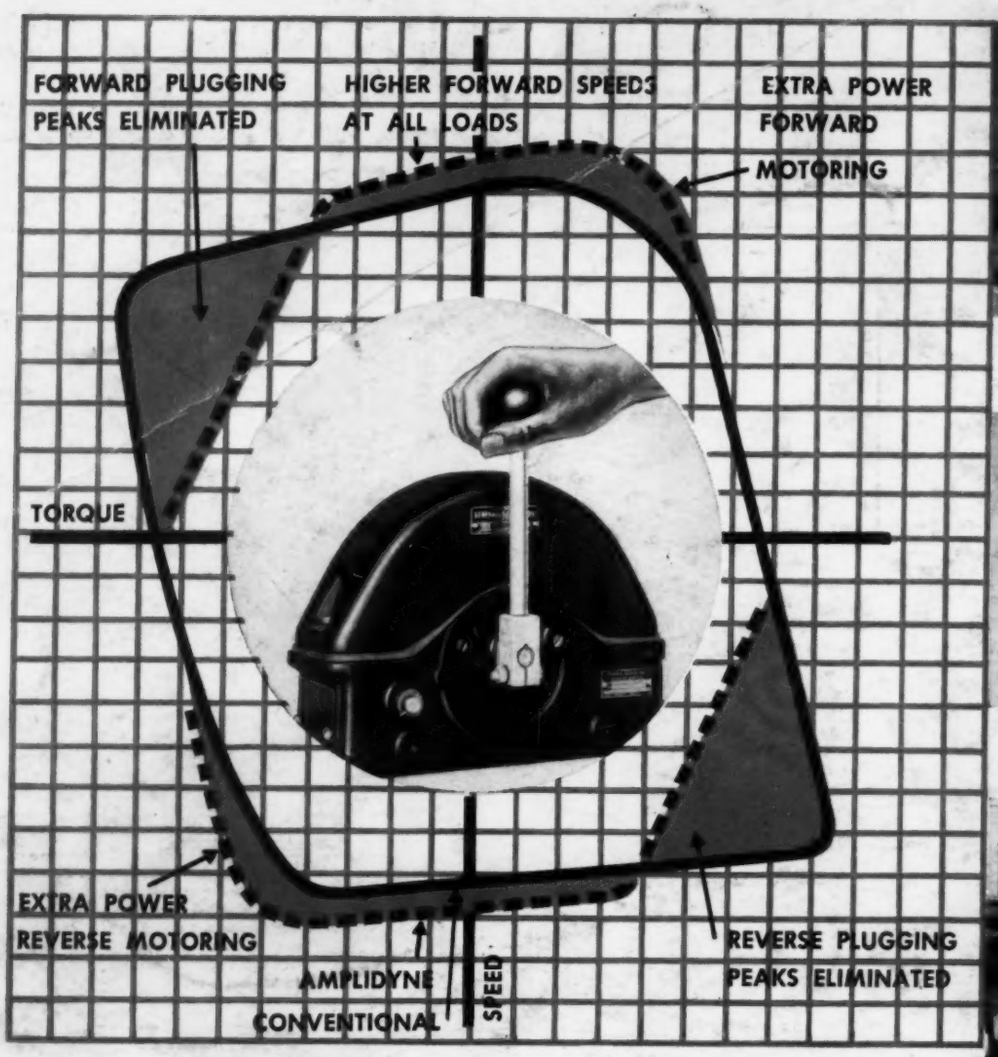
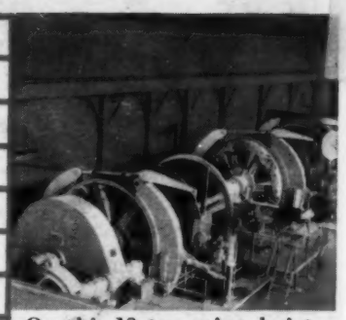




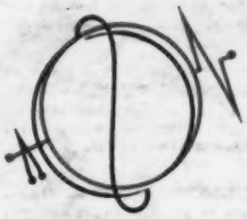
On this 13-ton mine hoist, the amplidyne holds almost constant speed regardless of load.

On a blast-furnace skip hoist, the amplidyne helped set a new high for tonnage handled.

On a blooming mill, the amplidyne reduced the number of control devices nearly 50 per cent.

Amplidynes' faster and smoother response increases the deadliness of bomber gun turrets.

13-ton sleight of hand



It needn't be a fast 13-ton mine hoist. It may be a power shovel, a saw-mill carriage, or a blooming mill. It may be a small, lightning-fast bomber gun turret, or a machine tool. In a thousand and one places, you'll find the G-E amplidyne translating the deft touch of an operator's guiding hand into action—doing it with new speed, with new precision.

As never before, man and machine are one!

The chart above shows graphically how amplidyne control affords extra power during motoring, and smooths out hazardous current peaks during rapid manipulation. By its instantaneous forcing action, the amplidyne boosts torque right up to maximum under fast-changing conditions. By its regulating and limiting action it sees to it that current and torque never exceed the values set as safe for the electrical system and machine.

You get faster, far smoother acceleration and deceleration than was possible with conventional control. Its instantaneous response helps speed output and gives electrical and mechanical parts greater protection, thus reducing maintenance.

How the amplidyne gets its remarkable amplifying power and hair-trigger response and how it simplifies the control of a wide range of machines are told in Bulletin GEA-4186. May we send your copy? *General Electric Co., Schenectady 5, New York.*

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